THE ENGINEERING REVIEW.

Formerly
Feilden's Magazine.

Vol. 10. JANUARY, 1904. No. 1. (New Series.)

The Conservation of Energy.

EVER since science became "popular" we have learned to expect, and not to be perturbed by, the most astounding statements on matters scientific in the daily press. Day after day we read sensational notices of this or that marvellous discovery, whose very essence is that it violates one or other of the fundamental and universally-accepted principles of dynamics or physics; and if we were to treat such writings seriously, we should be bound to confess that ours is indeed an Age of Doubt, and that the most wonderful discovery of all would be to find one child of faith. The discovery of radium—truly an extraordinary substance—appears to have led to a competition among newspaper journalists to outdo one another in the production of ridiculous statements, purporting to be the truth; but as no one—or, at most, very few persons—would accept unquestioningly statements regarding science from such a source, little harm is done. The case is otherwise, however, when such statements appear in a technical journal, intended to appeal to a class not ignorant of scientific principles, and supposed to be not only well-informed on the most recent advances made in research work but also logical in its discussion of old and thoroughly-tried doctrines. Yet we find our contemporary, *The Engineer*, in a recent issue, gravely insisting in a leading article that the doctrine of the conservation of energy is not proved, and that there is reason to doubt its accuracy.

Of course, radium is mentioned in support of this view, and we are told that the discovery of this substance has "at last rendered it possible to discuss the dogma without fear of scientific excommunication." If the writer had discussed the behaviour of radium, and had tried to prove his case by reference to that behaviour, one might at least have given him credit for an earnest attempt to pry into the unknown, and might have classed him among the genuine seekers after truth. But, beyond the reference we have quoted, nothing is said regarding radium; no attempt is made to show that its behaviour justifies the writer's conclusion, and no evidence is given to prove even that he is familiar with the properties of that substance. The matters with which he does attempt to deal are mostly connected with ordinary mechanics and with chemistry, and it is not difficult to show that his reasoning here is defective in the highest degree.

It is usually recognised in a scientific discussion that we must be agreed upon our definitions. The writer gives three definitions of energy—not his own, but, as he alleges, definitions ordinarily used. He says:—

"According to some authorities, energy is

capacity for doing work. According to others, it is motion. The most modern school hold that it is electricity."

Now, passing over the first and third of these definitions, as they are passed over by the writer, we should in the first place like to ask, Who are the "authorities" who have defined energy as "motion"? This is the only definition which the writer uses, and upon it his whole argument is based; but it is wholly wrong, and his argument is therefore reduced to an absurdity. The author's comment upon the statement we have quoted above, purporting to give true definitions, is this:— "After all, mere words signify very little." Evidently this is so in the case of the writer, but in a scientific journal we expect words to be well weighed, and we do not expect to find such a journal giving its support to a writer who professes to upset a fundamental principle of science by first stating the basis of that principle falsely, and then showing that, as stated by him, it is false.

As we cannot go into all the details of the article, let us set out here a few of the writer's theoretical arguments to show from what false premises he has started:—

"Let us suppose that we can form no concept of energy apart from motion. Then we may write at once, and logically, that the conservation of energy really means the conservation of motion. This view covers a tremendous area in physics."

It may be true that energy is most commonly made *manifest* to us when it is kinetic; but it is easy to form a concept of energy apart from motion, and the writer's supposition, on which he bases his argument, is therefore untenable. Does a coiled spring not convey to the writer any notion of its *capacity for doing work*? A little later on he speaks of something being

"quite consistent with the theory that energy means motion *and mass*."

Here a new element is introduced, but we are not told in what way the factors, motion and mass, are to be related to give energy. We need not trouble about this, however, as the writer at once drops "mass" out of his definition, and says:—

"If energy be motion, and a mass has no motion, then it has no energy."

Therefore, argues the writer, when we say that the energy spent in raising a stone to a height becomes potential, and is not lost, we are going directly contrary to the definition. Of course we are, for no one with even the most elementary knowledge of dynamics would accept that definition. When the writer goes on to consider what happens in the firing of a gun he is equally at sea, as he openly states that "the matter composing the charge *puts itself* in motion," and that this fact flatly contradicts the accepted proposition that "matter at rest cannot put itself in motion." No allowance is made for the effect of the spark in changing the state of the charge from a solid into gases with tremendous expansive power. But need we follow him further? If a man bases an argument upon false premises, it is only necessary to show that these are false to upset the whole structure. It would be amusing, if it were not almost pathetic, having regard to the place of publication, to read statements like these:—

"It is very easy to say, and therefore it is commonly said, that the precise definition of the words 'conservation of energy' is not wanted, because it possesses no value. We venture to hold that this is a mistake. It is of vital importance that we should know whether energy really is conserved or not. Is it true that motion can never be either lost or created, and if it is not true, how can either the one or the other phenomenon take place?"

"After all, it may yet be found that no theory of the conservation of energy that does not take into consideration the interrelations of the forces of the universe can be regarded as complete."

Let us assure the writer that he will find in any elementary text-book on dynamics a precise enunciation of the principle of conservation of energy. When he has mastered such books, and pursues his studies further, he will learn that the "interrelations of the forces of the universe" *hqve* all been taken into acount, as far as these are known; and that, so far, nothing has been found to upset the fundamental principle. We do not blame him for this effusion as, when a subject is imperfectly understood and knowledge badly assimilated, it is natural that doubts should arise; but what are we to say of our contemporary, that it should actually publish such opinions?

Influence of the Dimensions of Test Bars.

IT is generally recognised that the tensile strength of a test bar is materially affected by the length of the smallest part of the section between the enlarged ends. Further, it has been found that the longer the rod the less is its resistance to tension. If the material were perfectly homogeneous, the mere length of a rod should have no influence upon its strength, and the probable defect of strength depends upon the variability of the material of which the rod is composed. The percentage of extension in tensile tests is also affected by the dimensions of the test bar, although not in a precisely identical manner.

It is clearly a matter for regret that standard proportions for test bars have not been settled hitherto in Great Britain, since variations of length and cross-section necessarily give results which cannot be compared one with another. Standards have already been recommended and adopted on the Continent and in the United States, and it is probable that before long a similar course will be followed in this country. The subject is now under the consideration of the Engineering Standards Committee, and the Committee on Materials used in Ships and their Machinery have decided upon an 8-in. gauge length. Further, an investigation into the influence of the gauge length and section of test bars on the percentage of elongation has been undertaken for the committee by Professor W. C. Unwin, whose report has just been issued. This report is based almost entirely on tests of steel plate test bars furnished by Mr. Colville, of the Dalzell Steel Works, Motherwell, and by Mr. Dick, of the Parkgate Steel Works, Rotherham. The tests cover a wide range of conditions, and it is quite certain that the results afforded by them give far more complete information as to variations of elongation with the form of test bar than has been available hitherto. Tests were made on ten bars of ship plates and ten bars of boiler plates from Motherwell, and on twenty bars of ship plates and twenty bars of boiler plates from Rotherham, the plates varying in thickness from $\frac{1}{4}$ in. to $1\frac{1}{4}$ in. In the case of three plates it became evident that the quality was decidedly inferior, and the results were disregarded. Otherwise, the data obtained were remarkably consistent, as may readily be judged by the tables given in the report.

With regard to the real relative ductility of the Motherwell and Rotherham plates, the following are the chief conclusions deducible. (1) The relative ductility is practically the same, whether the test bars are of 1-in. or $\frac{1}{2}$-in. area. (2) The mean difference of elongation percentage in the series of 1-in. and the series of $\frac{1}{2}$-in. bars is 2·6 per cent. in the ship plates and 2·9 per cent. in the boiler plates. (3) The plates below $\frac{3}{8}$ in. thick have less ductility than thicker plates. (4) In plates over $\frac{3}{8}$ in. thick ductility diminishes as thickness increases. (5) Diminution of ductility with increase of thickness is less in boiler plates than in ship plates, so that while $\frac{3}{8}$-in. boiler and ship plates have about the same elongation percentage, $1\frac{1}{4}$-in. boiler plates have about 5 per cent. more elongation percentage than corresponding ship plates.

There are three possible courses for adoption in settling the standard forms of test bars :—(*a*) variation of gauge length, so that $l/\sqrt{a}$ (l = gauge length, a = local contraction) is kept constant, whatever the section of the bar; (*b*) fixity of gauge length and of sectional area; and (*c*) fixity of gauge length and fixity of width. The consideration of these courses by Professor Unwin leads to the conclusion that, if plates of all thicknesses be considered, no one rule can be rigidly adopted, and, consequently, that a compromise must be effected. Apart from the question of width, there appears to be little question as to the best form of the test bar, and the only point to be borne in mind is that nearness of the enlarged ends to the gauge length diminishes the percentage of elongation.

The standards suggested by Professor Unwin are :—(1) for plates from $\frac{3}{8}$ in. to $\frac{7}{8}$ in. thick, the gauge length to be 8 ins.

and the cross section not more than 1 in.; (2) for plates from $\frac{3}{8}$ in. to $\frac{7}{8}$ in. thick, the gauge length to be 8 ins. and the width not more than 2 ins. The first plan would certainly be most in accordance with the admittedly correct principle that the tests should show the real quality of the material. Professor Unwin evidently inclines toward the first alternative; and, in a note added after the report had been written, he states that a general relation has been found to exist between the general percentage of elongation and the gauge length and cross section of the test bar.

Thus, if, in a gauge length l for a bar of cross section A, the percentage of elongation is e, then $e = \frac{c\sqrt{A}}{l} + b$, where the first term on the right is the percentage of elongation due to local contraction, and the second is the percentage of general elongation, while c and b are constants for any given quality of material. The whole of the results are very fully and critically discussed by Professor Unwin, and his report is a most valuable record, irrespective of the immediate object for which it was prepared.

We may mention that further useful data were obtained from tests of some annealed and unannealed plates with varying percentages of carbon. These additional results throw light on the variation of elongation, both with variation of section and variation of hardness.

The New Edison Accumulator.

THE results, published almost simultaneously in England and France, of tests made by Mr. Hibbert, by M. Hospitalier, and by M. Janet of Edison's alkaline accumulator enable us at last to weigh up fairly definitely its technical value and possibilities. A good *primâ facie* case is presented for concluding that while, in its present form, its total energy output relatively to weight and space occupied is almost equal to that of any light-weight lead cell for which a reasonable durability can be claimed, it is able to endure without depreciation conditions of treatment which rapidly reduce the output and shorten the life of its rivals.

Used as a transportable cell, and more especially for automobiles, this may secure a decided preference for an Edison battery; but in other applications of electrical storage, where weight and bulk are in themselves of little moment, its irremediably low efficiency, coupled with its relatively high cost, seems still to put it out of consideration, apart from the fact that here the lead cell can possibly meet it on its own ground as regards durability under excessive discharge rates such as are experienced by traction regulator batteries.

As regards the exact nature of the active materials used in the Edison cell and of the chemical actions that take place, the several authors of the recent papers furnish but a nominal account and explanation, and one is inclined to conclude that on these points they are no wiser than anyone else who may like to study Kennelly's paper of 1901 and Edison's patent specifications. Indeed, these latter seem to indicate very clearly that the most fundamental features of the cell have not yet passed the evolutionary stage, and some very radical modifications are foreshadowed.

For instance, it is proposed to abolish the flake graphite blended with the negative active material of porous iron, and in its place substitute amalgamated copper, obtained by reducing an ammoniated solution of copper and mercury oxides, with the object of providing, so to speak, an unoxidisable framework of high conductivity in which the true active material is embedded. Besides this, M. Janet states in his report that the relative proportions of the positive and negative electrodes may undergo revision. It has been found that in the present cell, with equal electrodes, the fall of potential throughout the discharge is entirely due to the exhaustion of the nickel oxide, and cells have accordingly been made up with 20 positives to 10 negatives—that is to say, the thickness of the positives has been practically doubled by actually joining them in pairs in close juxtaposition, but with a small space between for the better circulation of the electrolyte.

From the few figures available it would appear that this alteration increases the watt-hour output for weight by about 25 per cent., at moderate rates of discharge; but, as might be expected, there is now a diminution of output as the rate increases more in accordance with what occurs in a lead cell, and probably, on a one-hour discharge or thereabouts, the gain of output is inconsiderable. It rather looks as if the interest created by Edison's cell would cause the whole subject of practicable alkaline accumulators to be reinvestigated and lead to advances from other directions; nor is it impossible that the lead cell, under the stimulus of this attack upon its monopoly of the field, may prove that it has not yet been developed to its utmost limits.

Mr. Samuel W. Johnson.

THOSE of our readers who closely follow the march of events in the railway engineering world will probably have already learned of the impending retirement of Mr. Samuel W. Johnson from his position of locomotive superintendent of the Midland Railway, a position which he has occupied for nearly thirty years. Mr. Samuel Waite Johnson was born at Bramley, near Leeds, and was educated at the Leeds Grammar School. He commenced his career as a pupil under the late Mr. James Fenton, at the large engineering works of Messrs. E. B. Wilson & Co., Railway Foundry, Leeds. He was afterwards engaged as manager of workshops for repairing locomotive engines at Peterborough, on the Great Northern Railway, which position he left to become works manager of the locomotive and carriage and wagon works of the Manchester, Sheffield, and Lincolnshire Railway Company, at Gorton, Manchester, for five years. In due course he obtained his first appointment as chief locomotive engineer of the Edinburgh and Glasgow Railway, and remained in that position at the absorption of that line by the North British Railway Company as locomotive superintendent of the Western division for two years. In 1866 he received the appointment of chief locomotive and carriage and wagon superintendent of the Great Eastern Railway, which he held for seven years, and it was during this time that he first introduced express four-wheel coupled bogie passenger tender engines. In 1873 he was appointed to the position he is now about to vacate on the Midland Railway, on which system Mr. Johnson has successfully introduced the various types of engines now in use. His four-wheeled coupled express bogie engine "Beatrice" took the gold medal at the Saltaire Exhibition in 1887, and his single driving-wheeled front bogie engine, No. 1,853, was accorded the Grand Prix at the Paris Exhibition in 1889; and also a similar type of engine, but larger, named "Princess of Wales," was awarded the Grand Prix at the Paris Exhibition in 1900.

Since the year 1900, to meet the ever-increasing requirements of the traffic, Mr. Johnson has introduced two new classes of four-wheeled coupled express passenger engines, and one enlarged type of six-wheeled coupled goods engine.

The new passenger engines were required to work the heavy and fast express trains, and in the first series a boiler with a Belpaire fire-box was introduced, and its size made considerably larger than any of the boilers previously built on the Midland Railway. The working pressure was increased to 180 lbs., and the tractive power is about 23 per cent. greater than the "Princess of Wales" type.

With a view to effecting economy, and taking even greater loads than those hauled by the engines just briefly noticed, the second series of passenger engines was introduced. In this case the size of the boiler was further increased, and the working pressure raised to 195 lbs., and the usual arrangement of two high-pressure cylinders was replaced by three cylinders, which are arranged on the compound principle. The engines so produced are amongst the most powerful in the country. They are 15 per cent. more powerful than the first series of engines described above, and in practice it has been proved that they are capable of dealing with light loads as economically as heavy ones.

New goods engines of a more powerful type have been built; the boilers and fireboxes have been made considerably larger than those of the old standard goods engines, and thereby these engines are capable of hauling loads 20 per cent. heavier than those taken by the older pattern.

Mr. Johnson is a member of the Institute of Civil Engineers, and was president of the Institution of Mechanical Engineers in 1898. The position that he is leaving is being taken by Mr. R. M. Deeley, with Mr. Cecil W. Paget as works manager. Their appointments will date from January 1st.

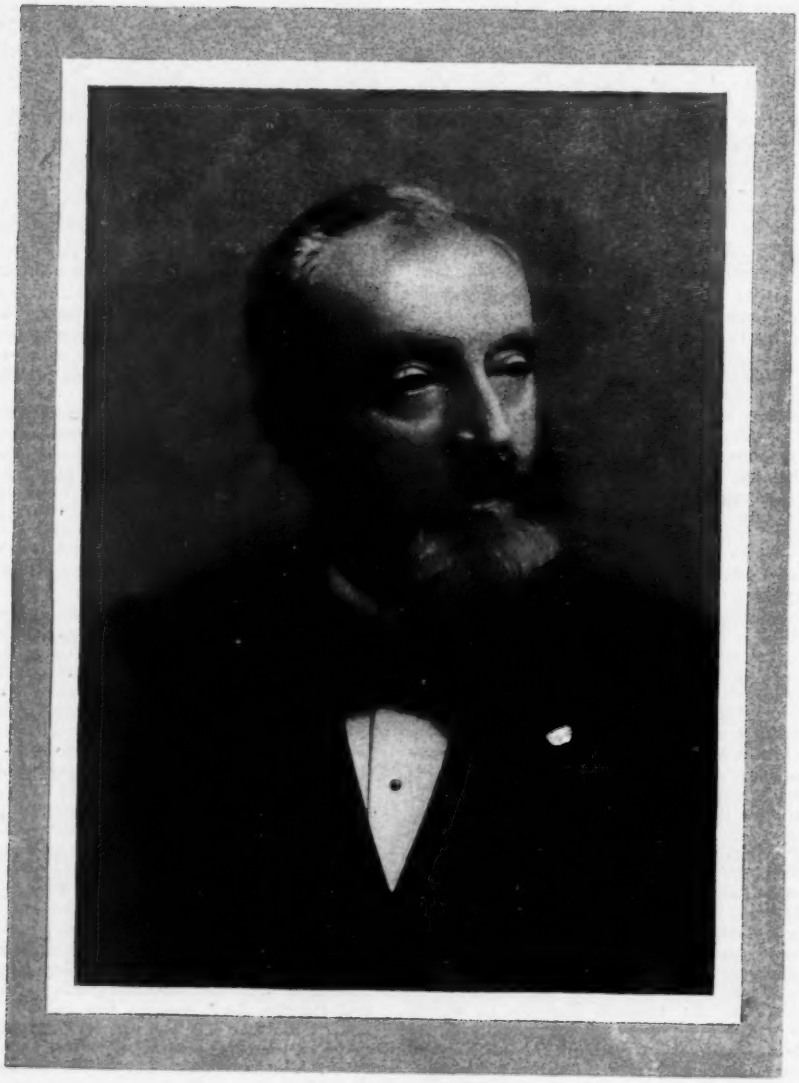


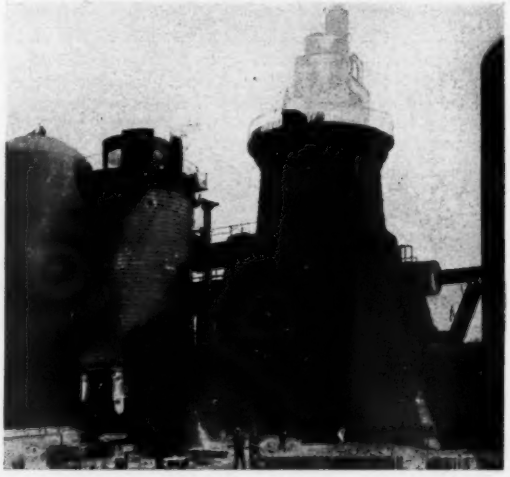
Photo by Geo. Pendry.] [*Nottingham.*

MR. SAMUEL W. JOHNSON, M.INST.C.E., M.I.MECH.E.

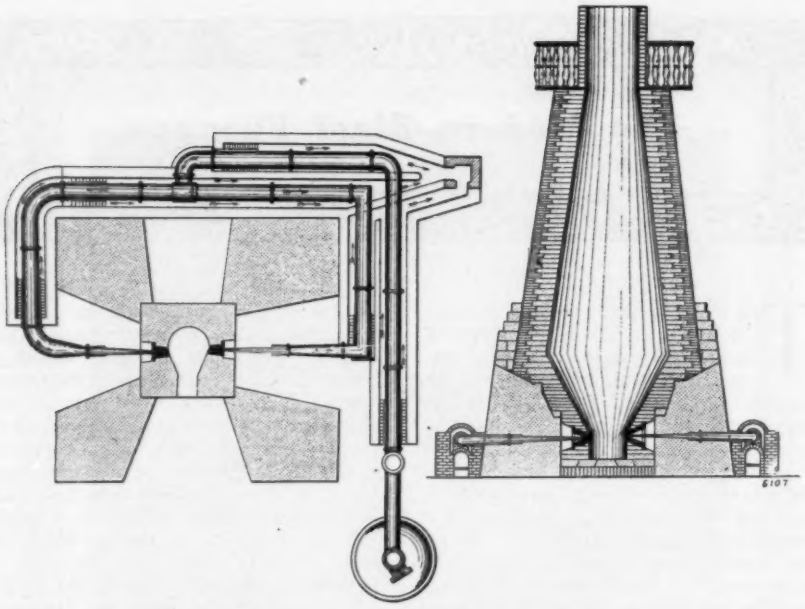
(See page 5.)

The Modern Blast Furnace.

THE blast furnace consists essentially of a vertical chamber, which is kept filled with the mixture of iron ore, flux, and fuel, and into the bottom of which enough air is forced to maintain the combustion, and keep up the necessary temperature. As the air comes in contact with the fuel combustion takes place, the coke burns away the iron and slag melt, and fresh solid material comes down to take its place. Thus a hot zone, or zone of combustion, is produced where the final reactions take place, and the charge is melted. This zone of combustion, however, never occupies a very large space in the furnace, and from it the hot gases—the carbon-monoxide produced by the combustion and the nitrogen from the air—rise upwards at a high temperature, heating in their ascent the charge above, and escaping somewhat cooled at the top of the furnace. In a low furnace the gases escape at a high temperature, and thus cause considerable loss of heat; but as the furnace is made taller, the temperature of the escaping gases falls till it reaches a minimum. One of the most marked differences between the old and modern furnaces is the increased height of the latter, and this increased height has been found to be attended with great saving in fuel. There is another reason why increased height is attended with economy. This is, that the oxide of iron should be reduced by carbon-monoxide near the top of the furnace; any oxide escaping reduction being reduced at the expense of the carbon lower down. With high furnaces the charge is much more likely to remain long enough in contact with carbon-monoxide at a moderate temperature to ensure complete, or nearly complete, reduction than with shorter furnaces. The limit of height will thus obviously be that at which the gases are fully cooled and the oxide is reduced by the carbon-monoxide in the upper zone of the furnace. Increased height, of course, entails increased cost of building, and a point is reached when any



A GOOD EXAMPLE OF AN EARLY SCOTCH BLAST FURNACE: GARTSHERRIE BLAST FURNACE NO. 1, ERECTED IN 1832, AND CEASED WORK IN 1896.



AN EARLY SCOTCH BLAST FURNACE, AT WORK AT THE CLYDE IRONWORKS ABOUT 1828. TWO TUYÈRES. A VERY EARLY TYPE OF HOT-BLAST STOVE, DESIGNED BY J. B. NEILSON, JUN.

saving that may be obtained is counterbalanced by the increased cost of erection. The increase in height has gone on from year to year till it has increased from about 40 ft. up to 80 ft. or 90 ft., which seems to be about the maximum advantageous height for furnaces working on coke under ordinary conditions.

There is another condition which limits the height of furnaces, and in some districts prevents the use of large furnaces—that is, the resistance of the materials of which the charge is composed to crushing. It is absolutely essential for good working that the charge should remain "open," so as to give free passage for the ascending gases, and this is impossible if the charge crushes to powder under the weight of the superincumbent mass of material, for in that case the draught will be impeded, and the furnace will work badly. It is obvious, therefore, that where any portion of the charge crushes easily only small furnaces can be used. This is the case with charcoal furnaces, which rarely exceed 40 ft. in height; and in Scotland, where raw coal is used, which gives an easily crushable coke, about 60 ft. is the limit of height for good work.

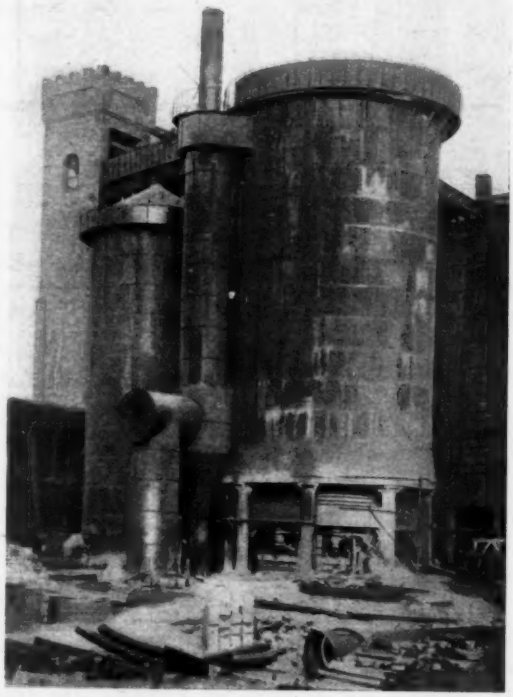
Other dimensions of the furnaces have increased in a similar manner, and for similar reasons. The furnaces are now built much larger in diameter, the increased diameter having to a large extent the same effect as increased height in ensuring reduction by carbon-monoxide and cooling the gases by reducing the rate at which the gases pass upwards. There are other dimensions which are fixed by quite different conditions. The diameter at the throat is fixed by the nature of the charging arrangement and its capacity to distribute the charge evenly over the top. The diameter of the hearth is limited by the power of the blast to penetrate into the charge, for there must be no part

beyond the reach of the blast. With the moderate blast pressures generally used in this country (5 lbs. to 7 lbs.) the maximum diameter of hearth is 8 ft. or 9 ft., whilst with the much higher pressures now coming into use (7 lbs. to 11 lbs.) a hearth 11 ft. or 12 ft. in diameter can be used.

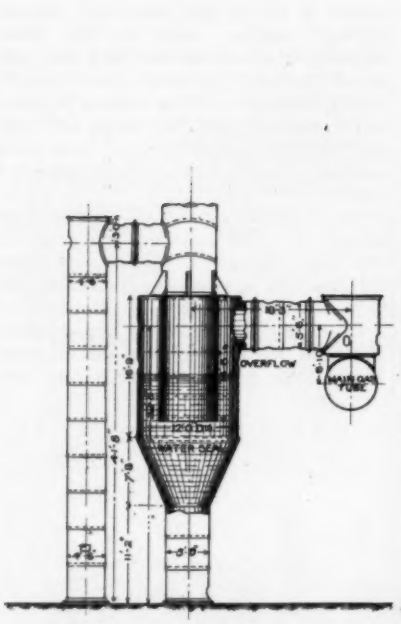
The height of the furnace, its maximum diameter, and the diameter of the hearth being fixed, the contour may still vary very considerably, according to the height at which the bosh—or point of maximum diameter—is placed. This is usually so fixed that the angle of the bosh—that is, the angle of a line drawn from the widest diameter to the top of the hearth will be inclined at about 75 degs. to the horizontal, this angle varying in modern furnaces only within narrow limits. The tendency is also to give the interior of the furnace a flowing contour by rounding off all sharp angles.

Externally the furnace has been changed even more than internally. The older furnaces were solid masses of masonry, the idea apparently being to keep in as much heat as possible. Modern furnaces are, on the other hand, iron shells lined with a layer of brickwork 5 ft. or 6 ft. thick, this being sometimes so far reduced that the charging platform and appliances must be carried on a separate framework. The older iron-cased furnaces had a double lining, an outer one of ordinary brick and an inner one of fire-brick, the two being separated by a thin layer of ashes. This is now frequently abandoned, one lining of fire-brick only being used. All modern furnaces are completely cased with iron. The superstructure is carried on a series of iron columns, so as to allow free access to all parts of the furnace, and the tendency of late has been to greatly increase the height of these columns, so as to allow freer access of air to the bosh, and thus to facilitate cooling; and in the latest furnaces, which are driven hard, the bosh is further cooled by bronze or iron cooling blocks, through which a current of water can be made to circulate, being built into the masonry, or by a stream of water being made to circulate round it so as to keep it cool.

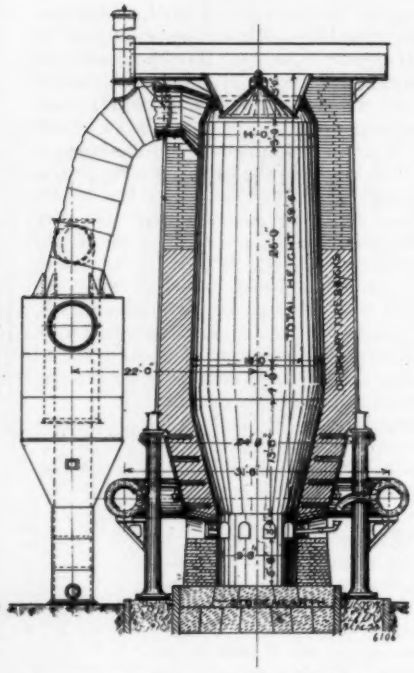
The introduction of the hot-blast by Neilson in 1828 worked a revolution in iron smelting, and at once—even when the blast was only moderately heated—led to an enormous increase in the output of iron and a decrease in the consumption of fuel, as will be seen from the following figures of the results obtained at the Clyde



MODERN TYPE OF SCOTCH BLAST FURNACE (GLENGARNOCK).



DUST CATCHER FOR BLAST FURNACE (GLENGARNOCK).



A MODERN SCOTCH BLAST FURNACE (GLENGARNOCK). TEN TUYÈRES AND COOLERS IN THE BOSH.

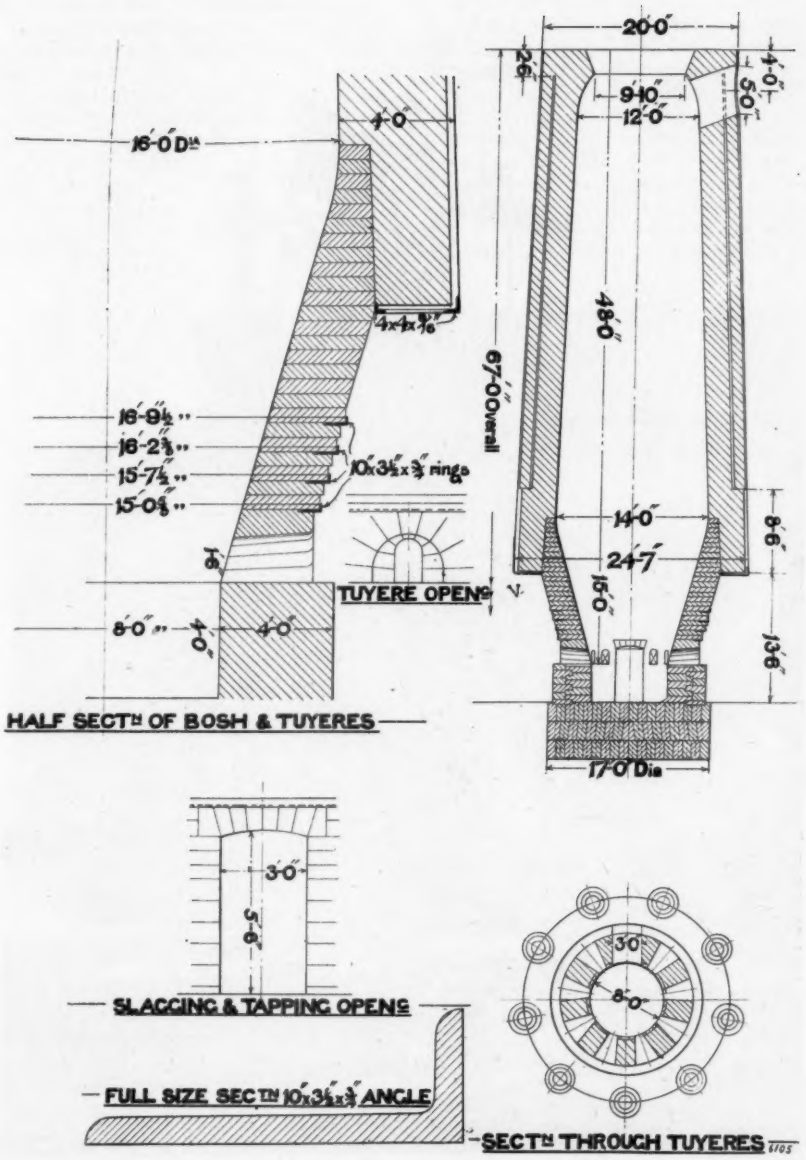
Ironworks, where the invention was first put into practice:

		Weekly Make per Furnace.		Coal per Ton of Iron.		
		Tons.	Cwts.	Tons.	Cwts.	Qrs.
1829	Jan. to Aug.: Coke and cold air	36	18	8	1	1
1830	Jan. to Aug.: Coke and hot air, 300° Fahr. ...	54	1	5	3	1
1833	Jan. to Aug.: Coke and hot air, 600° Fahr. ...	61	1	2	5	1

With the old pipe-stoves only a moderate temperature (about 600 degs. Fahr.) could be obtained, but in 1860 Mr. Cowper invented the fire-brick regenerative stove, and higher temperatures became easily obtainable. Now, with such stoves, the blast is heated to about 1400 degs. Fahr.

The introduction of the hot blast has modified the conditions of working in many ways. The fuel consumption is much reduced, part of the necessary heat being supplied by the hot blast; and as the air is hot there is less expansion, and the absorption of heat by expansion being less the temperature of the zone of fusion is much higher. It might at first sight seem that a taller furnace would be needed to cool the hotter gases, but this is not so, as the quantity of air used is much less.

The rate at which a furnace is driven—that is, the amount of coke burnt and ore reduced in a given time—depends on the amount of air sent in. The conditions are so favourable to combustion that any amount of oxygen that can be given will



A MODERN SCOTCH BLAST FURNACE (WISHAW). EIGHT TUYÈRES.

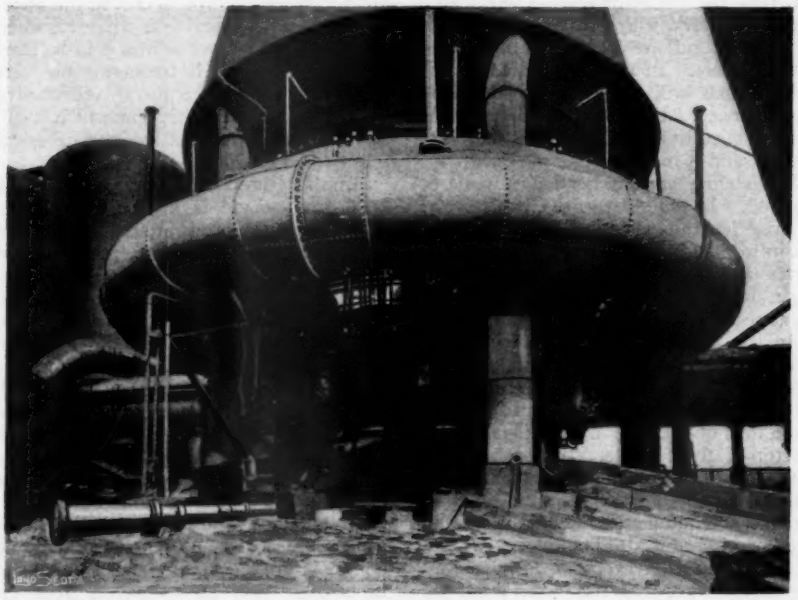
MODERN AMERICAN AUTOMATIC CHARGING BLAST FURNACE.

be converted into carbon-monoxide, and a larger supply of air means an increased action and a more rapid descent of the charge.

For rapid driving a large supply of air is necessary, and the furnaces are therefore fitted with eight or ten tuyères, and these may be up to 6 ins. or 7 ins. in diameter. With very rapid working the bosh must be efficiently cooled, and the tuyères themselves must be provided with at least double water coolers.

coming into use, an output of 1,200 tons to 2,000 tons of iron per week is obtained, the consumption of fuel per ton of iron being about the same in each case.

There is no doubt that the system of hard driving will become general, but ironmasters are by no means unanimous as to its advantages. On the old system a blast furnace would last without relining about 20 years, and there are many running that have been in blast even longer, whilst with the new system the furnace will not



HEARTH OF A MODERN BLAST FURNACE OF THE AMERICAN TYPE.

Modern Developments.

The most important developments of the modern iron industry are in the direction of hard driving, and therefore large outputs. In the older furnaces, and still in Scotland, Staffordshire, and some other localities, the driving is slow, and an output of 300 tons to 400 tons of iron is obtained per week per furnace. In Middlesborough and in North Lancashire, where American methods are

stand more than five or six years. The construction of a furnace for rapid driving is much more costly than one for slow driving.

The introduction of rapid driving necessitates a complete change in many of the accessories of the furnace. The amount of air supplied must be very much larger, and more powerful engines must therefore be provided. In all new works ,the

American system of giving each furnace its own engines is being adopted in place of the old system of blowing all the furnaces from one set of engines on the same main. This is undoubtedly an improvement, as it makes the furnaces independent. The engines are built so as to be capable of giving a pressure of 20 lbs. if required.

Great improvements have been made in blowing engines, most of those now used being of the direct-acting, or of the more recent quarter-crank, type. Internal combustion engines, in which the waste gas from the blast furnaces is used, are already at work, with great success, in a few works, and are being put down at several others. In one new works three such engines will be supplied to each blast furnace. Parson's turbine is also being applied to supplying air for the blast furnace, and is in use at one works.

Much more efficient heating stoves are required. In the older works, two stoves, or even less, are used for each furnace, but in works for rapid driving at least four stoves per furnace are required, and sometimes, in addition, an additional pair to act as regulators.

As the output of the furnaces is increased the amount of material to be charged increases also. In round numbers, for 1,000 tons of iron obtained, about 3,500 tons of material must be raised to the top of the furnace. It becomes extremely difficult to supply this quantity of material by the ordinary method of hand-barrows, and automatic charging has therefore been introduced. The bucket system of the Brown Conveyor Co. is largely in use in America, and has been fitted to several furnaces in this country, and is being fitted to many others—indeed, to nearly all the new furnaces.

In this system the ore and fuel are charged into buckets, which are run up an inclined plane, and automatically emptied into a revolving distributor, whence they fall on to the bell, and are then charged to the furnace, as usual. With this apparatus, not only is the charging rapid and uniform, but the saving of labour is very considerable.

It also becomes much more difficult to remove its products with sufficient rapidity. In dealing with the slag, Howden's slag-conveyor is largely used. This consists of a series of iron moulds carried on an endless chain, and slowly moved past the slag notch, so that each mould is filled in passing, and on its passage the slag solidifies, so that it is turned out of the mould solid into a truck put to receive it.

Similar machines have been suggested for dealing with the metal, but have not come into extensive use in this country. Founders select their pig by the appearance of the fracture, and this is very different when the iron is cast in the metal moulds of a pig-machine to what it is when cast in sand. When the iron is to be used for steel-making it is frequently not cast into pigs at all, but is run by means of a ladle into a metal mixer, from which it can be distributed to the steel furnaces as required.

Another direction in which advances have been made is in the recovery of by-products. Various attempts have been made to utilise slag, with more or less success, for the manufacture of paving-blocks, Portland cement, and other purposes; but these have, as yet, been used only on a very small scale. Indeed, when one considers the enormous amount of slag in existence, and being produced each year, it is obvious that its general utilisation, unless for the manufacture of something for which there is an enormous demand, would lead to production far in excess of that which could be utilised.

In Scotland and some other districts where raw coal is used for fuel, tar and ammonia are recovered; and in other districts these may be recovered from the ovens in which the coal is coked.

The gas is the most important by product, and this is now always utilised to some extent. It is invariably used for heating the blast, hot-blast stoves with separate fires being extinct; this, however, requires only a small portion of the gas, and the remainder is used for steam-raising. For this purpose, however, the gas is unsuited, as it burns with a non-luminous glare, and the use of the gas in this way is very wasteful. As, however, there is more gas than is needed, this has not been a matter of much moment. The

use of the gas in internal combustion engines is very much more economical; but for this purpose the gas must be previously washed, to remove dust, etc. By so using it, however, a large amount of power will be obtainable over and above that needed for supplying air to the furnaces, and which therefore may be used for other purposes. It must be remembered that only about one half the energy of the fuel is utilised in the blast furnace, and the other half can be obtained by combustion of the gas.

It will be seen that the recent developments in blast-furnace practice have been mainly in the direction of securing increased output, and at the same time of economising labour, the latter being to a large extent subsidiary here, though of much more importance in the United States, where wages are much higher. There is room in many cases for a large saving of labour, and when one sees the wasteful methods used in many of our works one is apt to wonder whether cheap labour is after all a good thing.

There is no doubt that our pig-iron industry is undergoing a revolution, that in the near future the average output per furnace will be largely increased, and that the cost of production will probably be reduced. At the same time there seems to be a steady improvement in the uniformity of the material made, and this has been largely brought about by buyers specifying the composition of the iron they need. This uniformity is less marked in pig-iron for foundry purposes, where specifications of composition are less generally used.

A. HUMBOLDT SEXTON, F.C.S., F.I.C.

High-Speed Engines.*
Valve Motions.

(Continued from Vol. IX. Feilden's Magazine, page 399.)

As to valve motions, the high-speed engine builder has no great range of choice. Whatever he adopts must be coupled up; no loose tackle of any kind has a shadow of a chance at 600 revs., or even a good deal less than that. This reduces the actions to those of eccentric motions, and how to make the best of these is the main question at issue with the designer. It has been shown that piston-line inertia is very great; and proportionately, pound for pound, so is that of valve motions. An 8-in. stroke engine would have a valve travel of at least 2 ins., probably more; so that, in a similar way to the piston-line dealt with in a previous article, if the valve motion weighs 80 lbs. or so, having ¼ stroke and ¼ the weight, instead of an inertia of 6,800 lbs., the valve-line would have one of $\frac{1}{12}$, or 566 lbs., which is a considerable item. It is clear that the rod must be pretty strong, and the bearing considerable, to stand a reversing pressure of 566 lbs. or so, and that the connecting pins must be distinctly large. All builders have found this out in course of time, and many valve motions seem as strong as small piston-lines. A point of considerable import in this connection is the fact that there is no compensating action of any kind for relieving the shock of the inertia in this line, as there is in that of a piston. As a matter of fact, it is about as difficult to keep knock out of a valve motion as out of a piston-line, or more so; and as two rattling elements make more noise than one, wherever it is possible, it is better to have one eccentric line than two.

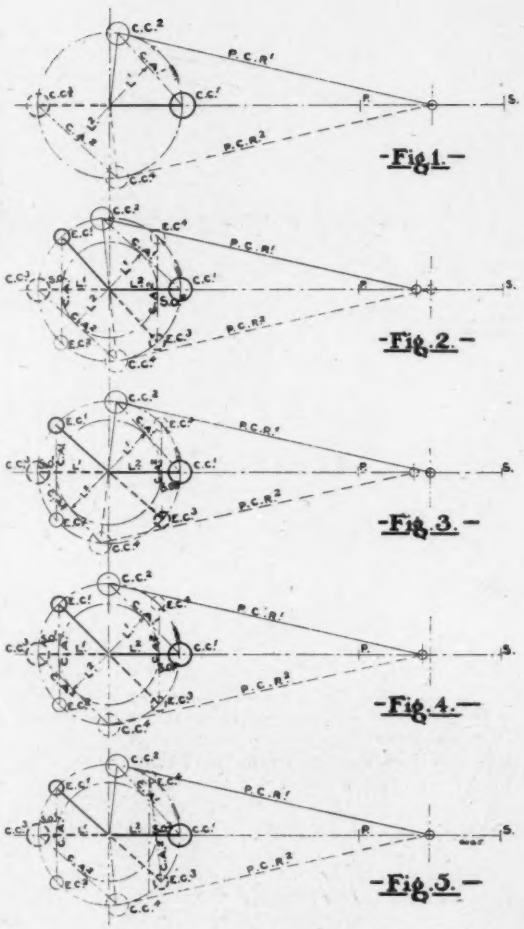
How to get all the necessary actions of variable cut-off and the other distribution features out of one valve and one eccentric motion is a geometrical problem which is not to be despised. Where throttling is used for governing, this is simpler.

Before entering upon a detailed description of the three types of valve and valve motion, which are shown in the accompanying figures, it may be best to go over the effects of the piston connecting-rod on the steam distribution of a valve which is actuated by a coupled-up eccentric motion, especially with regard to such valves as are required to perform singly the whole of the functions of distribution.

It goes without saying that any deviation of the crank end of the piston connecting-rod from the centre line of the engine shortens the distance on such line of the piston from the crank, and that the shorter the rod, relatively, the greater is such variation of distance; and that, in fact, the movement of the piston does not correspond with that of the crank as regards the direction of the centre line of the engine. Shortly, except at one instant, the linear travels of the crank centre differ from those of the cross-head or piston. On the other hand, the connecting-rod of the valve is relatively so long in regard to the throw of the eccentric and travel of the valve, and the variation of the linear distance of the valve centre to the eccentric centre on the centre line of the engine is so little, that the move-

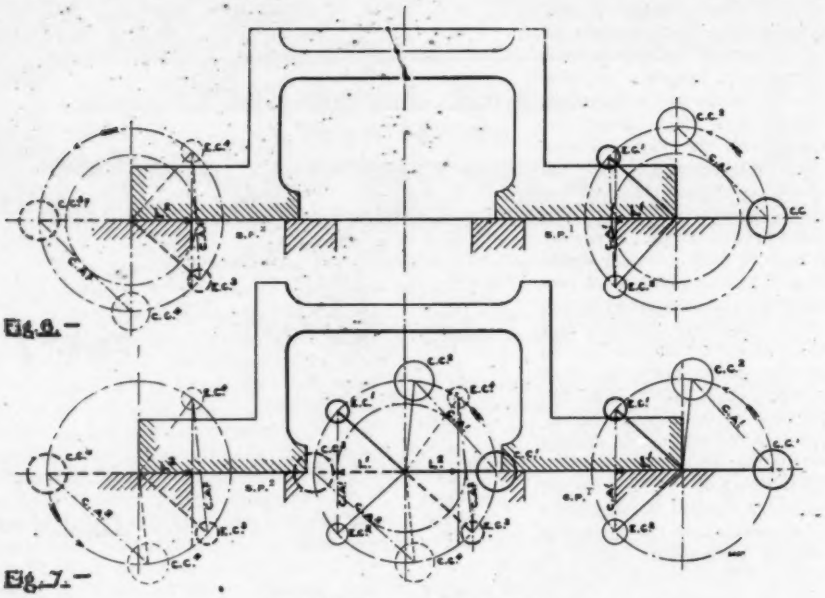
* For previous articles, see *Feilden's Magazine*, pp. 395, 399, Vol. 9; pp. 101, 197, 410, Vol. 8; pp. 305, Vol. 7; pp. 19, 216, 432, Vol. 6; pp. 576, Vol. 5.

ment of these centres on such line does practically correspond or harmonise. There is thus a constant variation of relationship in the two lines of the piston and valve going on throughout the cycle of motions of the engine, and the essential actions can only be made to correspond at one point in each stroke. A perfect action of piston stroke would demand that equal lead or pre-admission should take place in each stroke (out and in), and that the cut-off should also be at the same point in each stroke; the latter, for the purpose of equalising the impulse of the piston, and adding to the regularity of the action of the engine. As with an ordinary central arrangement of eccentric line the foregoing double requirement cannot be had, it follows that the actions must be arranged to give those results which are most necessary to the proper working of the engine. These latter are, of course, the cut-offs. Whatever the leads may be, the cut-offs must be right, or a greater variation in the motion of the crank will take place than that which unavoidably results from the reciprocating action of the piston. Figs. 1, 2, 3, 4, and 5 are made to show the above points and features, and are constructed for a usual high-speed engine connecting-rod of $2\frac{1}{4}$ times the length of the stroke of the piston.



FIGS. 1 TO 5.—HIGH-SPEED ENGINES.

In Fig. 1 the large circle represents the path of an engine crank. CC^1 represents the first position of the crank centre at the commencement of the stroke, CC^2 the position of the crank centre at half out-stroke of piston, CC^3 crank centre at end of out-stroke and commencement of in-stroke, CC^4 is the crank centre at the half in-stroke of the piston, PS is the piston stroke, and PCR^1 the piston connecting-rod at half out-stroke, while PCR^2 is the same half in-stroke. CA^1 is the chord of the crank angle for half out-stroke, and CA^2 the chord of the crank, and for half in-stroke. CA^1 and CA^2 should respectively embrace the steam time for the out and in-strokes. It is seen that these angles are not equal or near equal, and this, as before stated, is the chief cause of difficulty in designing a suitable valve.



FIGS. 6 AND 7.—HIGH-SPEED ENGINES.

A lap of valve which would be suitable for the out-stroke would not be suitable for the in-stroke, and a setting of eccentric centre (immovable) which would open to steam on the dead centre out-stroke and cut off correctly would have a considerable "lead" for the in-stroke, and would, moreover, cut off before the piston reached the proper position.

Figs. 2 and 3 are for demonstrating these features. The lettering refers similarly to Fig. 1, the extra references being EC^1, EC^2, EC^3, EC^4, which are the four eccentric centre positions corresponding to those of the crank centres.

Fig. 2 is made to show that if the steam chord CA^2 of the in-stroke is transferred to its proper position for the eccentric movement between ec^1 and ec^2, with a consequent lap of valve L^2 (as Fig. 1), and the setting for the out-stroke to open to steam on the dead centre, the lap at the two ends of the valve being equal, at the natural cut-off time ec^2, the out-stroke piston would have travelled more than half-stroke, all the centres being fixed and revolving together. The in-stroke would, of course, have a correct action. Fig. 3 is to show that if the lap is made to suit the out-stroke or L^1, and the setting of the eccentric, as before, is made for opening to steam on the dead centre, the out-stroke action would be correct; but the in-stroke would fall short of its correct cut-off—an action just the reverse of Fig. 2.

The mean of the crank angles of Fig. 1, it is evident, is 90 degs., and if a lap (equal at both ends of valve) be taken for these as in Fig. 4, the result of the movements is that the cut offs are at the same point in the piston stroke, but not in the centre of that line; the out-stroke cut-off being too late, and the in-stroke cut-off being too early. Clearly, to get an equal time of cut-off in the two strokes, some compromise must be made, and at the expense of the uniformity of the steam opening time. Therefore, in Fig. 5, beginning with a correct dead centre steam time and cut-off for the out-stroke,

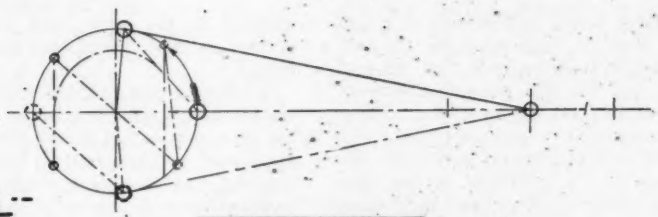


Fig. 8.—

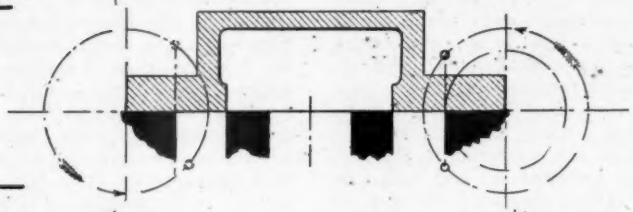


Fig. 9.—

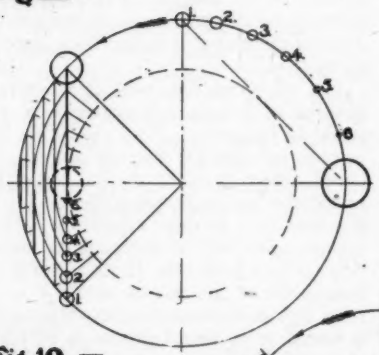


Fig. 10.—

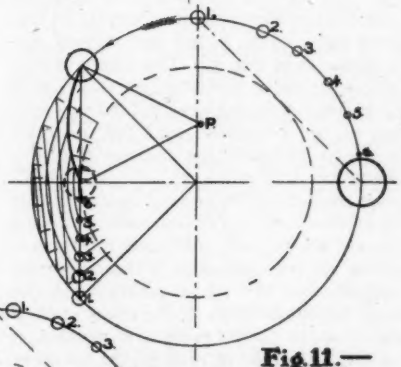


Fig. 11.—

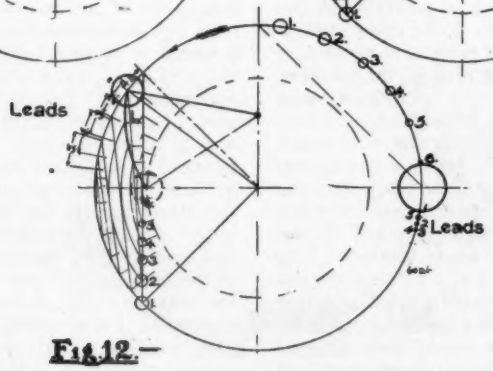


Fig. 12.—

FIGS. 8 TO 12.—HIGH-SPEED ENGINES.

and fixing the eccentric for that, L^1 would be the lap for that stroke. With the crank on the dead centre for the commencement of the in-stroke, the eccentric centre would be at $e\ c^3$. Now, in order that the in-stroke crank-angle for correct cut-off may be made, the eccentric centre must reach $e\ c^4$ before the valve closes, and this would give L^2 as the lap for the in-stroke. It is evident that as steam opens

at *e c s*, there would be a considerable lead for the in-stroke, with none for the out-stroke, and it is shown later that no lead can be had for the out-stroke without increasing that of the in-stroke. These arrangements give correct cut-off time with one valve on both out and in-strokes. No equal lap on the half-travel of the valve can give equal cut-off, and any valve made with equal surface on each side of the D or exhaust cavity must be set out of centre in its travel to get equal cut-off. For further illustrating the foregoing points, Figs. 6 and 7 have been made to a larger scale, also showing a valve on ports, and the application of Fig. 5 diagram to the construction of a correct lap and lead. In Fig. 6 the central diagram consists of an eccentric-motion circle, also serving as the crank path. The letters and figures are the same as in Fig. 5. The figure of the valve is shown at half-travel (of valve), and the steam line at both ends of the figure—that is, the out-stroke and the in-stroke ends—are placed on the steam edge of the steam-port $S P^1$ and $S P^2$. The lap in both cases reaches to the vertical centre-line of the motion circle. $S P^1$ is the steam-port for the out-stroke, and $S P^2$ that for the in-stroke. It is clearly seen in the out-stroke diagram that the steam comes on at the dead central position of the crank, and is cut off at the correct point in its revolution for the half-stroke of piston. On the other hand, the lap-line of the in-stroke shows a considerable lead or pre-admission for that stroke. The relative positions of the crank and eccentric centres are the same in both cases. Fig. 7 is made to show that the same valve and eccentric position, when set with the laps standing equal on the ports, at half-travel, would divide the lead of the in-stroke in Fig. 6 between the out and in-strokes, and would give steam during 90 degs. motion of the crank in both cases, but of course this would give unequal cut-off. The inside lap shown is such as would be required to retain the steam to about $\frac{11}{12}$ equally on both strokes. With no inside lap the exhaust would be, generally speaking, too early for a stationary engine. It should be observed that any attempt at equalising the cut-off by reducing the lap at the ends of the valve, without at the same time shifting the eccentric centre, would alter the grade of cut-off.

All the foregoing figures refer chiefly to double-acting engine-valve motions, and the next step in this part of the subject in hand may, perhaps, best be taken by considering the case of a single valve for distribution and automatic governing as applied to this class. For this purpose Figs. 8, 9, 10, 11, and 12 have been made. Fig. 8 is a diagram of centres and steam angles similar to Fig. 5, and Fig. 9 is the resulting valve, which also shows the eccentric-motion circles applied to the admission edge of the cylinder steam ports, with thoroughfares, etc. Figs. 10, 11, and 12 are for the purpose of illustrating the principles of the necessary governing movement of the eccentric centre from late cut-off to zero.

Fig. 10 shows the crank and eccentric position at the commencement of the out-stroke in full circles. In a case of no lead or pre-admission the distance of the steam chord, shown from the vertical centre line of the motion circle, would be the lap for the time of a 90-degs. admission. If the acting centre of the eccentric be moved down the chord-line to the horizontal centre line of the motion circle, it is evident that in its revolution in this position it would at no time (with such lap) open the port at all, but would bring the valve admission edge just to the edge of the port. In point of fact, it would be travelling in a smaller circle, as shown in the right of Fig. 9. In case of any pre-admission or lead the eccentric action would open the steam port to the extent of the lead only. This is the action of a locomotive link motion when the die is in the centre of the link, and it is this action which it is necessary to closely imitate when one valve is used for the purposes of steam admission, variable cut-off, and exhaust. The exact action, it is easy to see, could be obtained only by the use of a straight slot of some kind for carrying the eccentric centre.

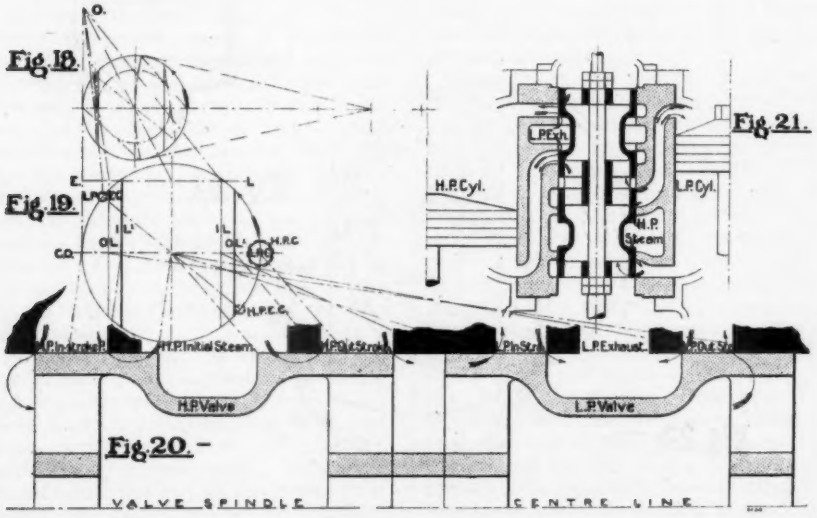
Following the arcs, which are drawn from and to the steam chord, it is readily seen that, in the different positions of the governing action, the steam admission

varies according to such positions, and that with the eccentric centre on the centre line of the engine, there would be no opening of the valve. Relatively also, the governing movement increases the angular advance of the eccentric centre, until it becomes opposite to the crank centre. The steam opening, of course, diminishes, as the arcs show, and the angular motions of the eccentric centre during the different admission times, corresponding with those of the crank from the commencement of the stroke, give the necessary variations of cut-off. These points of cut-off are marked by corresponding circles and figures on the steam chord and the crank path.

Fig. 11 shows the application of a rotary action of the eccentric centre about a point, as *P*, the point being so placed that the eccentric centre moves from the end to the middle of the steam chord, with no lead at either of these points, but giving lead at all intermediate positions, the lead decreasing the admission time in the intermediate points. In this figure also, as in Fig. 10, corresponding angles or cut-off points are marked by small circles and figures. The best radius for the governing motion is fixed by practical considerations in regard to the admissible size of the eccentric sheave, surface velocity, etc.

Fig. 12 shows a practical arrangement of centres, which would give the lead or the out-stroke which is necessary in the high-speed engines, and which would bring the eccentric centre inside the steam chord in the zero position of cut-off; this, of course, being necessary for ensuring absolute governing action. In addition to the marking of the cut-off points, as in Figs. 10 and 11, the variations of the lead due to the governing movement of the eccentric centre are shown by radial lines and arcs figured to correspond with the cut-off points referred to. The figures are diagrammatic; for actual application due consideration of the lap and action of the valve on the in stroke would have to be given, as well as a sufficient margin of governing motion of the eccentric centre allowed, for ensuring an action to zero cut-off on both strokes. The method shown can be readily applied to the in-stroke lap.

Fig. 18 is a trial diagram of crank path and eccentric circle for half stroke cut-off,



FIGS. 18 TO 21.—HIGH-SPEED ENGINES.

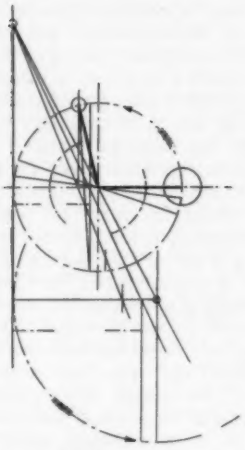


Fig. 22.—

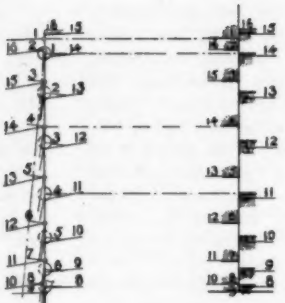


Fig. 24.—

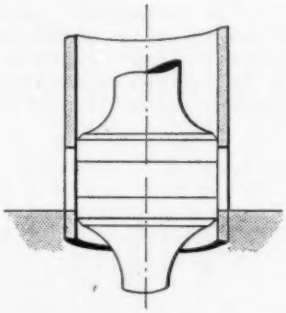


Fig. 25.—

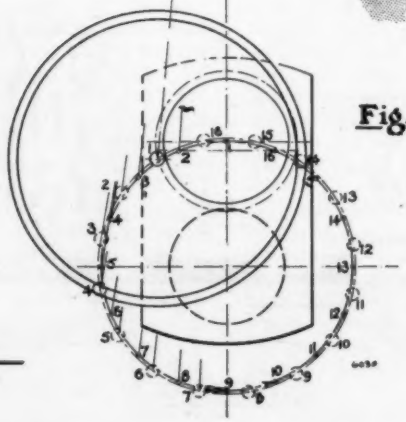


Fig. 23.—

FIGS 22 TO 25.—HIGH-SPEED ENGINES.

including both out and in-strokes, in the first place, for a single cylinder. With the exception of an allowance for lead on the out-stroke, this diagram is similar to No. 5. The steam openings and laps are expanded by triangles radiating from point *O*, until the former gives a sufficient passage area for some given cylinder. This expansion in the figure is carried to a line *EL*, which is parallel to the line of valve motion. From line *EL* perpendiculars are dropped from the expanded points, and with a motion circle so produced a new lap figure, Fig. 19, is formed. The fine lap lines belong to the original, Fig. 18, and are suitable, with the crank and eccentric in the usual position, for a valve with outside lap. The intention, however, is to make a compound valve which will work an out-stroke and an in-stroke by the same movement of the valve by means of one eccentric. This means that one portion of the valve will have to be made with inside lap, as ordinarily understood, while the other portion will require outside lap. The position of the steam supply determines which of these shall be the high-pressure and which the low-pressure valve.

Applied to a pair of twin-compound cylinders of the Belliss type, in which the initial high-pressure steam is introduced into what is usually the exhaust or cavity of the high-pressure valve, it follows that this valve must be constructed with inside lap, and that the exhaust from it must take place by the outside edge, which will put the steam into the internal space of the two valves and chest. From there it will be admitted to the low-pressure cylinder by the outside edges of the low-pressure valve, and thence exhausted in the ordinary way. The arrows in the figures indicate the direction of the flow of the steam.

Returning to Fig. 19, seeing that the low-pressure piston is worked by outside lap, when the low-pressure piston is in the position of the commencement of its out-stroke, and the crank at *LPC*, full-line circle, the eccentric centre, with lead, would be at *LPEC*. At this time, as the cranks are taken to be on opposite centres, the high-pressure crank would be at *CO*, and the eccentric would be "following" the high-pressure crank, while it is "leading" the low-pressure. When the high-pressure crank arrives at *HPC*, the eccentric centre will naturally be at *HPEC*. The difference in the valve action in these two cases is that, whereas the admission for an out-stroke by an outside lap is brought about by a movement of valve in the same direction as the out-stroke, the admission for an out-stroke by inside lap requires a movement of valve in a *contrary* direction to that of the piston. This entails, in the construction of Fig. 19, the transference of the out-stroke lap, *OL* (fine line) to the opposite side of the motion-circle centre at OL^1 (strong line), the distances from the said centre being, of course, equal.

In the same, but reverse, manner the in-stroke lap (fine line) *IL* must be transferred to IL^1 (strong line), in order that the lap lines may correspond with the necessary pairs of laps and with the opposite crank centres. Fine dotted lines show the relations of the positions or lap lines with the corresponding points in Fig. 20, which is a valve-construction diagram. The collective application of this to the working of twin-compound cylinders is shown in Fig. 21, where arrows show the origin and direction of the steam pressure and current.

Figs. 22, 23, 24, and 25 refer to the design of valve motions and valves for engines of the central-valve single-acting type, according to the invention of the late P. J. Willans, Esq., M. Inst. C. E. Fig. 26 is a vertical section of such an engine with compounded cylinders. The steam is admitted from the pressure chest, to which the hollow piston trunk extends, by a circumferential ring of holes or ports into the interior or bore of the trunk, and from thence to the high-pressure working cylinder by a piston-valve, which alternately opens and closes a second set of ports situated in the trunk close above the working piston. As the piston descends the upper set of ports pass through the trunk gland packing, and so cut off the initial steam supply to the bore of the trunk. The upper end of the trunk is stopped by a plug or piston fixed on the valve-rod or

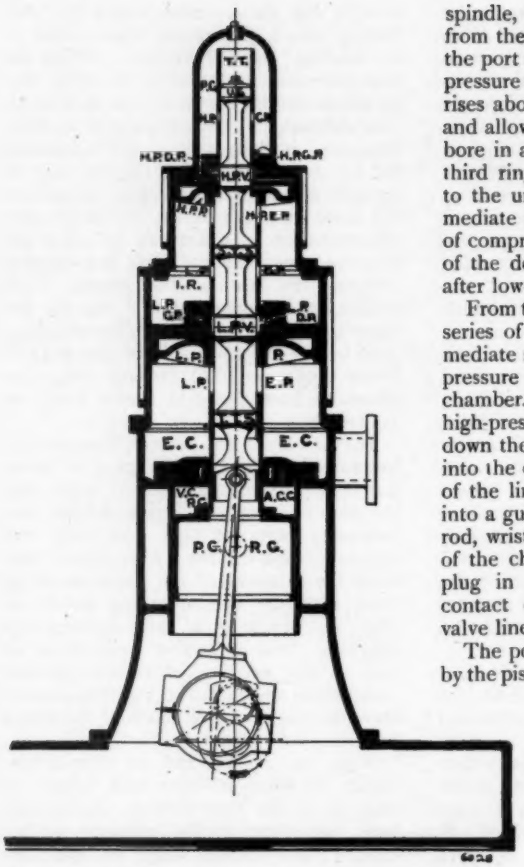


FIG. 26.—VERTICAL SECTION THROUGH A WILLANS ENGINE.

P.C.	Pressure chest.
T.T.	Trunk tail.
U.S.	Upper stop.
H.P.C.P.	High-pressure cut-off ports.
H.P.G.P.	,, ,, gland packing.
H.P.V.	,, ,, valve.
H.P.D.P.	,, ,, distribution ports
H.P.P.	,, ,, piston.
H.P.E.P.	,, ,, exhaust ports.
S.T.S.	Second trunk stop.
I.R.	Intermediate receiver.
L.P.C.P.	Low-pressure cut-off ports.
L.P.G.P.	,, ,, gland packing.
L.P.V.	,, ,, valve.
L.P.D.P.	,, ,, distribution ports.
L.P.P.	,, ,, piston.
L.P.E.P.	,, ,, exhaust ports.
T.T.S.	Third trunk stop.
V.C.R.G.	Valve connecting-rod guide.
A.C.C.	Air compression chamber.
E.C.	Exhaust chamber.

spindle, which keeps out the chest steam from the distribution valve mentioned after the port cut-off has taken place. The high-pressure valve, in continuance of its action, rises above the high-pressure piston ports, and allows the steam to return to the trunk bore in a lower section, from which, by a third ring of ports in the trunk, it passes to the under-side of the piston and intermediate receiver or space. Some degree of compression takes place here by reason of the descent of the high-pressure piston after low-pressure cut-off time.

From the intermediate space, by a second series of trunk ports and valve, the intermediate steam is worked through the low-pressure cylinder and into the exhaust chamber. A second stop-piston below the high-pressure valve prevents the passage down the trunk of the low-pressure exhaust into the crank chamber. The lowest part of the line of valves and stops is formed into a guide for the eccentric connecting-rod, wrist-pin, or gudgeon. The pressure of the chest steam on the upper stop or plug in the trunk maintains constant contact of the wearing surfaces in the valve line.

The port faces in this engine are carried by the piston motion, as also is the eccentric centre by the crank, and the action of the distribution valve thus becomes relative, but, all the same, in effect practically similar to that of an ordinary engine; and the arrangement of the centres is performed by a similar diagram.

Returning to the valve-motion figures—Nos. 22, 23, 24, and 25—the first is a motion circle, as ordinary, set out with a sufficient lap for port cover, which it will be seen is relatively little. In advance of this a certain amount of lead is shown for getting the port well open in advance of the piston motion. The valve motion in this class presents none of the difficulties of the double-acting type, as only the out-stroke has to be provided for; and, further,

in this particular engine no special provision for compression is required. There can be no question in the mind of the expert that Willans' engine possesses many very remarkable features of efficiency and simplicity, especially in the matter of valve motion and compounding, and where no automatic cut-off is desired. The valve opening is almost the maximum speed of the eccentric motion, and the cut-off, which is virtually performed by the piston, is probably quicker than any other method in use, not excepting detached actions such as the Corliss.

The steam time of Fig. 22 is very nearly the full stroke, and the exhaust about the same, so far as the distribution valve is concerned, the intermediate compression being brought about by the closing of the low-pressure cut-off ports as they descend into the low-pressure gland packing. The lines and proportions obtained by the trial motion circle are expanded to the lower part of the figure for producing any required opening. Having fixed the steam ports, cover, and lead, however, no more than the simplest mental arithmetic is required for fixing the position of the eccentric centre with regard to the crank.

For ascertaining the exact relative motion of the trunk ports and valve, Fig. 23 has been made, which follows the relative positions of crank and eccentric centres round the circles which they describe; and by means of a pair of connecting-rods, which are assumed to be of equal length, the relative motions of the wrist ends are set out, these corresponding very closely with the actual movements of the trunk and distribution valve, although the connecting-rods of these are not equal in the example (Fig. 26). The marks and numbers of the various positions of the crank and wrist correspond in Fig. 23. For the sake of clearness these marks are projected to a line (Fig. 24), and shaded on the proper side, so showing on inspection the steam opening at the various points in the stroke; thus Nos. 4 and 5 give the maximum opening of the valve, the piston motion points being lined off the centre line on the left, while the valve motion points are on the right. The unshaded lines here show the return stroke of the trunk ports and the valve edges. Fig. 25 is simply an enlarged view of the distribution valve and trunk ports.

J. H. DALES, A.M.Inst.C.E.

The Economy of Live Steam Feed Heaters.

A FEW years ago it was proposed, in order to lessen the strains in the shell due to expansion and contraction which occur when cold feed-water is pumped into a boiler, to heat the feed-water by means of live steam taken from the main boiler or from an auxiliary boiler. This was tried, with more success than the proposer estimated, as it was found that the coal consumption of the steam plant was at the same time considerably lessened. This fact was received with considerable scepticism among every class of engineers, so-called "practical" men not being able to conceive that the double process of first producing the steam and then condensing it to heat the feed-water could lead to any economy over the direct process of heating the feed-water in the boiler; while scientific engineers, understanding that from a thermodynamic standpoint this process of heating by the condensation of live steam is in a greater degree "non-reversible" than is the more gradual heating by mixing in the boiler and therefore thermodynamically more wasteful, cast grave doubts on the accuracy of the experiments. These, however, have been repeated so often and with such a coincidence in their results, that there is no longer any doubt that this method of live steam heating does lead to more economical working—more so in some plants than others—the reason why never having been clearly understood.

Thermodynamically this method of heating is bad, so that we must inquire into the physical causes which may effect an economy out-balancing this thermodynamic loss.

Now it is well known that the flow of heat through a boiler flue-plate will, *ceteris paribus*, vary as the difference of temperature between the two sides of the plate.

Also if, due to a too sluggish circulation of water in the boiler, the film of water, or of water forming steam and bubbles directly in contact with the flue-plate, which film is of a higher temperature than the mean temperature of the boiler, is not removed with sufficient rapidity, this difference of temperature will be reduced, and not so much heat will pass into the boiler. Anything which tends to check a sufficient circulation will therefore be directly opposed to economy, more of the furnace heat being rejected to the chimney. But whereas the entrance of water into the boiler, which has already been raised up to boiler temperature, does not interfere with the circulation, the admission of cold feed will certainly affect the circulation, the effect depending on the position of the feed-pipe in the boiler relatively to the flues, as if placed above the flues the descending stream of cold water will very effectively check the ascending stream of hot water and of bubbles. It would appear, therefore, that the whole of the economy gained by this method of heating the feed-water is due directly to increased efficiency of circulation in the boiler.

The most correct—thermodynamically—method of feed heating with a compound engine would be to raise the cold feed-water, by means of the exhaust steam from the low-pressure cylinder, to the temperature of that steam. Then, by means of a steam jet from the

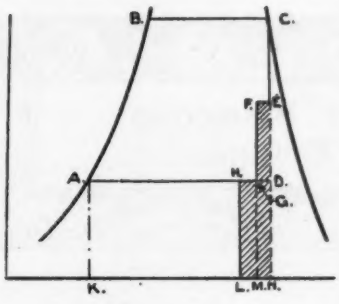


FIG. 1.

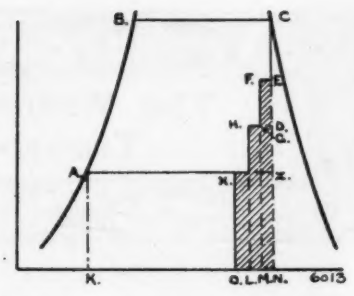


FIG. 2.

low-pressure receiver, raise this feed-water to the temperature of this receiver steam; and then, in a third step, by means of a steam jet from the high-pressure receiver, to raise the feed-water to the boiler temperature. Considered by the aid of the $\theta\phi$ diagram the efficiency of the cycle, in the case of feeding by direct pumping of cold feed into the boiler, will be the ratio of the area $a\,b\,c\,d\,a$ to the area $k\,a\,b\,c\,d\,n\,k$. The efficiency of the compound heating cycle will be the ratio of the area $a\,b\,c\,e\,f\,g\,h\,a$ to the area $k\,a\,b\,c\,e\,f\,g\,h\,l\,k$ (Fig. 1). The area $n\,e\,f\,g\,m$ represents the heat given to the feed from the low-pressure receiver, and the area $m\,g\,h\,l$ represents the heat given up to the feed by the exhaust from the low-pressure cylinder.

In the case of a triple-expansion engine heating the feed-water in four stages, from the high-pressure, intermediate, and low-pressure receivers, and from the low-pressure exhaust, the $\theta\phi$ diagram would be as in Fig. 2, the efficiency getting nearer and nearer that of an engine working under Carnot's cycle the more the subdivision of stages of heating the feed is carried out.

A. H. GIBSON,
B.Sc. (Vict.), Wh. Exh.

The Widnes and Runcorn Transporter Bridge.

A VERY long period of time has elapsed since the first proposal was made to connect the banks of the Mersey by a bridge in the neighbourhood of Widnes. In fact, nearly a century has passed by since those inhabiting the country on either side of the river commenced to agitate for suitable means of communication. At that time, great inconvenience was experienced in this respect, as, with the exception of the bridge at Warrington and the ferries at Liverpool, there were absolutely no adequate facilities for cross-river traffic between the districts on opposite sides of the Mersey. After a certain amount of agitation, the matter was taken up in the year 1817 by a strong local committee. A report on the subject was then obtained from Telford, who advised the erection of a chain suspension bridge at an estimated cost of about £90,000.

The bridge, as designed, was to have had a span of 1,000 ft. between the centre of two masonry towers, and a clear waterway, at the centre, of 70 ft. above high-water level.

The committee reported favourably upon the scheme, but owing to lack of financial support the project was abandoned. It may be interesting for some of our readers to know that a model of the proposed bridge, to the scale of 20 ft. to 1 in., was made by Telford, and that this model is still in existence, and may be inspected in a building belonging to the Shropshire Union, at Ellesmere Port.

Although several schemes have subsequently been proposed for crossing the river at Runcorn, nothing practicable was brought forward until the advent of the present scheme about three years ago. A strong company was then formed, with Sir John T Brunner, Bart., M.P., as chairman, Sir Henry Seton-Karr, M.P., as deputy-chairman, and other gentlemen as directors representing local interests and the towns of Widnes and Runcorn. The opposition, which is always evidenced against any useful public work, was duly represented by 11 petitions against the Bill in the

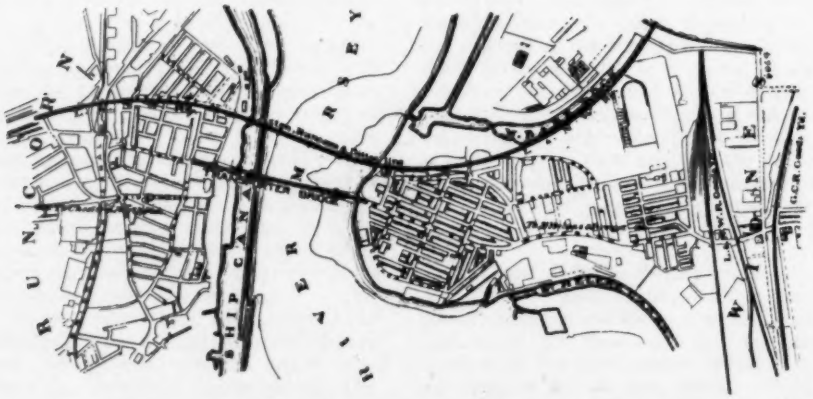


FIG. 1.—WIDNES AND RUNCORN TRANSPORTER BRIDGE: PLAN SHOWING THE POSITION.

FIG. 2.—WIDNES AND RUNCORN TRANSPORTER BRIDGE: GENERAL VIEW.

Parliamentary session of 1900, but fortunately without success.

As may be seen by the general view in Fig. 2, the new bridge is of the "transporter" type. It is interesting to recall the fact that the principle was originated by Mr. Charles Smith, of Hartlepool, who designed a bridge of this kind for crossing the river Tees at Middlesbrough some 30 years ago. Several bridges of the same type have since been built on the Continent, but in constructional details they are not the same as the bridge now under consideration.

Except that the approaches to it are at a low level, the bridge is exactly the same in general construction as an ordinary stiffened suspension bridge. In the case of a river with low banks, such as the Mersey, this is a great advantage, as the heavy cost of a high-level approach is obviated. All traffic will be carried over the water in a car suspended to the underside of the bridge, and ample accommodation will be provided both for vehicles as well as for foot passengers.

It so happens that the new bridge is being erected on the same site as that chosen by Telford, and the clear span, 1,000 ft., is also the same as that proposed in the earlier scheme. Fig. 1 is a plan showing the exact position of the present structure.

The bridge is approached on either side by new roadways, which are nearly flat, and built between stone and concrete retaining walls up to the water's edge. One pair of the main towers (Fig. 3) is built on the southern side of the Manchester Ship Canal, and the other pair (Fig. 4) on the foreshore on the northern bank of the river. Access to these towers from the approach roads is given by steel elliptical girders, supported on cast-iron columns, carrying a steel trough flooring upon which a wood-block roadway is laid, 35 ft. wide between the parapets, with footpaths 6 ft. wide. In order to provide adequate space for marshalling the traffic, and for the erection of waiting-rooms and other necessary buildings, the roadway is widened out to 70 ft. in front of the towers.

The towers are constructed entirely of steel, and rise to a height of 190 ft. above high-water level. Each tower has four legs, bolted to cylinder foundations. Altogether there are 16 cylinders, 9 ft. in diameter, one for each leg of the four towers. These cylinders are of cast iron, filled with concrete and sunk into the solid rock, which on the Widnes side is quite near the surface but on the Runcorn side is 35 ft. below the Ship Canal level. On this side of the river the cylinders were sunk by means of compressed air. All the cylinders are bolted to the rock bottom, and suitably connected by bracing, so as to form a perfectly rigid foundation, to which the tower legs are bolted. Each leg is 4 ft. 10 ins. wide at the base, tapering to 2 ft. 3 ins. wide at the top, and the legs are strongly braced together with horizontal and diagonal members. At the bottom of the towers they are spaced 30 ft. apart, and at the top 6 ft. 9 ins. apart.

Fig. 5 is an enlarged view of a tower, showing clearly the details of the steelwork. The towers of each pair are 70 ft. apart, and they are braced together with horizontal and diagonal frames. On the top of the towers are fixed the saddles for carrying the steel cables, the saddles being placed on steel rollers to compensate for variations in the

length of the cables due to the loads and the temperature. Above the saddles on each tower there is a platform 10 ft. 6 ins. wide, and above this will be built a powerful electric lantern, 7 ft. 6 ins. diameter and 8 ft. high.

There are to be two main cables of 19 steel ropes bound together, each rope being built up of 127 wires 0·16 ins. in diameter, thus making a total of 2,413 wires for the whole cable. The diameter of each cable is about 12 ins., and the weight more than 240 tons.

A noteworthy point is the high tensile resistance of the steel wire employed for the cables, the ultimate strength being 212,800 lbs. per sq. in. As the sectional area of steel in each cable is about 50 sq. ins., the total strength amounts to more than 10,640,000 lbs. per cable. During manufacture, the interstices between the wires of the ropes are filled with bituminous compound, the spaces between the ropes are similarly filled, and the whole is covered with the same compound and finally wrapped with two layers of strong sailcloth saturated with bitumen.

In forming the backstay anchorages, the solid rock on each side of the river was cut away for a depth of about 30 ft.; three sets of cast-iron anchor plates and the bottom lengths of the anchor bars were then placed in position, and long bars of steel rail section were stacked, transversely and longitudinally, upon each plate. Then, the first length of anchor bars being already in position, the whole of the anchor pits were filled and rammed with 1 : 7 Portland cement concrete, up to the top of the rails. The next lengths of anchor bars were then put in position, and concrete was filled in as before. This process was continued until the top links were fixed, these being in short lengths in order to form the curve leading to the backstays, and a cast-iron pillow was embedded in the concrete at each top joint. The top lengths of the anchor bars finish at three steel crossheads, to which are attached the 19 cable ropes with screwed adjustments, the ropes of the cable being left unbound for a distance of about 50 ft. from the anchorage.

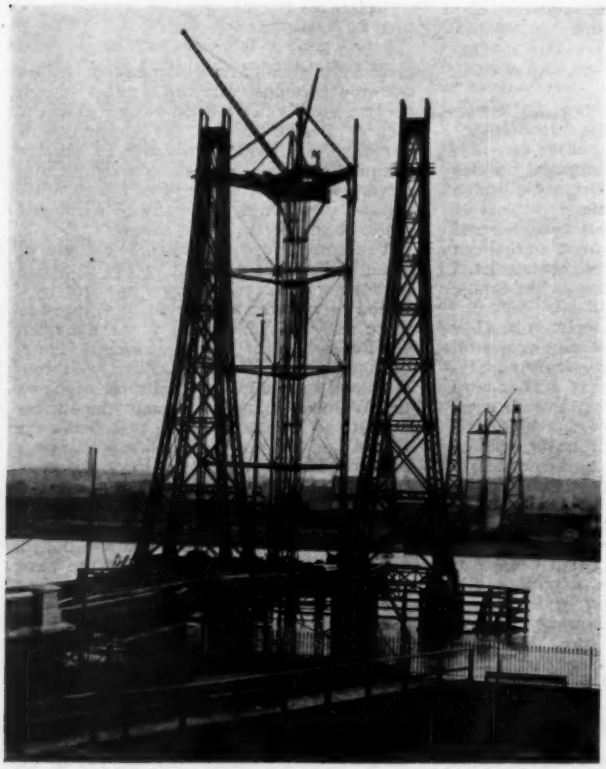


FIG. 3.—WIDNES AND RUNCORN TRANSPORTER BRIDGE: ONE PAIR OF THE MAIN TOWERS.

Two longitudinal stiffening girders, 18 ft. deep, are suspended from the main cables, at the distance of 35 ft. apart, and at such elevation that there is a clear headway of 82 ft. above high-water level. These two girders will be firmly braced together horizontally to withstand wind pressure, which causes the heaviest stress to which the structure will be

subject. The stiffening girders are hinged at the centre, thus reducing to a minimum the serious stress that would otherwise be caused by expansion and contraction of the supporting cables. When it is stated that the girders will rise and fall as much as 2 ft. 9 ins. for a range of temperature of 60 degs. Fahr., above and below an average temperature of 60 degs. Fahr., the necessity for this provision becomes very evident.

For the purpose of providing for longitudinal expansion and contraction, the girders are fixed to a very ingenious arrangement, consisting of vertical rockers, which are also designed to carry the ends of the girders which project beyond the towers, so that the transporter may be run into the docks or stations at the extremities of the bridge.

Rails are fixed upon the lower flanges of the stiffening girders to carry the trolley from which the car is suspended.

The trolley is about 77 ft. long, and has 16 wheels on each rail. It is propelled by two electric motors, each of about 35 b.h.p., furnishing a considerable excess of propelling power, so that strong head winds shall not interfere with the expeditious operation of the car.

The motors are fixed to a special form of bogie in the trolley, so that if considerable curvature of the bottom boom of the stiffening girders should be caused either by temperature changes or by load, the driving wheels shall always be in full contact with the rails.

The automatic and hand brakes provided are so powerful that, even when travelling at full speed, the car can be pulled up within its own length.

The transporter car consists of a platform 55 ft. long by 21 ft. wide, suspended from the trolley by steel wire ropes, so hung that they prevent either side or end oscillation of the car. The car will be capable of holding at one time four two-horse loaded wagons and 300 passengers, the latter being protected from the weather by a glazed shelter, having folding doors at the ends and sides. The operator's cabin, containing the switchboard and other controlling appliances, is placed upon the top of the car, so that the operator may have a full view of the course, and have the car entirely at his command. The time occupied by the car in crossing will be about 2¼ mins., and allowing time for loading and unloading, it will be quite possible to make nine or ten trips per hour. The bridge, approaches, and car will be illuminated with the electric light, and fog-signals and bells are to be provided for use when necessary. The bottom of the car will be about 12 ft.

FIG. 4.—WIDNES AND RUNCORN TRANSPORTER BRIDGE: PAIR OF THE MAIN TOWERS.

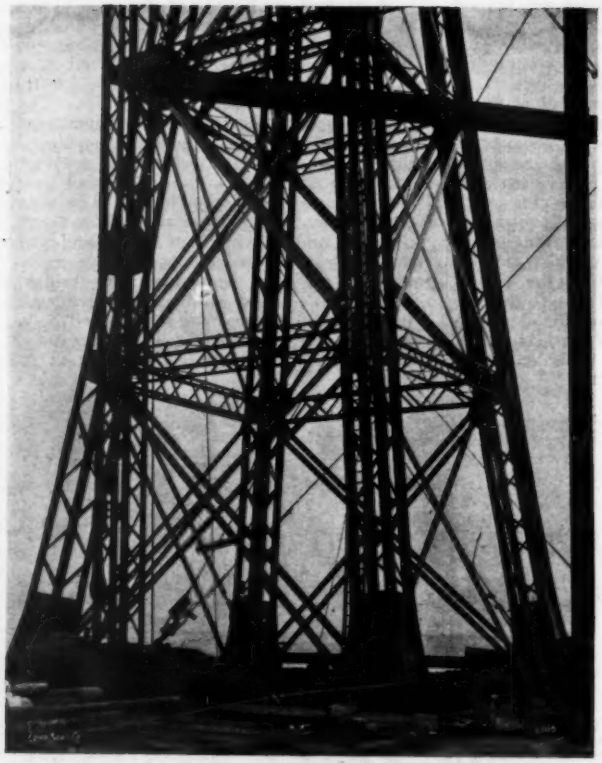


FIG. 5.—ENLARGED VIEW OF A PORTION OF ONE OF THE TOWERS.

above high-water level, and will clear the Ship Canal wall by about 4 ft. 6 ins.

As no available supply of electricity exists on either side of the river, a generating station has been equipped at the bottom of the Widnes east tower. The plant comprises two Crossley gas engines, 70 b.h.p. each, one being spare; two dynamos, a booster and accumulator battery of about 246 cells, with all the necessary switchboards, fittings and connections. The station is built in three stories—on the bottom or ground floor being the engines, dynamos, booster and switchboard; on the second floor the accumulator batteries; and on the top floor the water tank.

When completed, this bridge will have a longer span than any bridge in the United Kingdom designed for carrying road traffic, the clear span over the Mersey and Ship Canal being 1,000 ft., as before stated.

Including Parliamentary expenses, the structure will cost about £130,000. It is probable that a high-level bridge with approaches would have cost fully three times this amount, and the traffic to be anticipated would scarcely be sufficient to justify so large an outlay on the part of a private company.

On the other hand, the convenience and comparatively small cost of the bridge now approaching completion should be sufficient to ensure financial success, and to confer an immense benefit upon residents and others on either side of the river.

Mr. John J. Webster, M.Inst.C.E., of Westminster, and Mr. John T. Wood, M.Inst.C.E., of Liverpool, are the engineers for the bridge, the resident engineer being Mr. L. H. Chase, M.Inst.C.E.

The masonry work in the approaches and anchorages has been carried out by Messrs. W. Thornton & Sons, of Liverpool; the contract for the steel superstructure is in the hands of Arrol's Bridge and Roof Company, of Glasgow, by whom the sinking of the cylinders, the construction of fenders and scaffolding was sublet to Messrs. Holme and King, of Liverpool; the construction of the towers, approach girders, and cylinder foundation being sublet to the Widnes Foundry Company. The steel cables have been made by the St. Helens Cable Company, and the whole of the electric installation and equipment, including the lighting of the structure, is being carried out by Messrs. Mather & Platt, of Manchester. Our photographs show the position of work at the present time, and it is believed that the bridge will be ready for opening early next year. **W. N. T.**

Experiments with Rapid-Cutting Steel Tools.

(Continued from Vol. IX., FEILDEN'S MAGAZINE, page 541.)

Results as to the Variation of Cutting Force with Area of Cut and of Cutting Stress with Speed.

THE force exerted by the tool in cutting was determined by deducting an assumed lost horse-power from the gross electrical horse-power observed on the trial, the difference being the net or effective cutting horse-power; this, being reduced to foot-lbs. per minute, and divided by the speed of cutting, gives the force exerted. The figures so obtained have been plotted as ordinates, upon a base of area of cut, in Fig. 7.

For steel they show that the cutting force is simply proportional to the area of cut, and that this force has the following approximate values:—

	Per sq. in.
For soft steel (fluid compressed)	115 tons
,, medium ,, ,,	108 ,,
,, hard ,, ,,	150 ,,

It must be remembered, however, that the speeds at the lighter cuts were from two to four times as great as for the heavier ones; and that, as the cutting force for any given section of cut may vary with the speed, the relation between the cutting force and the area cut *at any one given speed* may differ from the above linear law.

In order to test this point, a series of trials were made upon medium steel by means of the lathe-tool dynamometer (constructed for actually observing the force acting upon the tool), at a constant speed of cutting of about 35 ft. per min. Several different cuts were taken at each of two traverses, viz.: $\frac{1}{16}$ in., $\frac{1}{8}$ in., $\frac{1}{4}$ in., and $\frac{3}{8}$ in. cuts at $\frac{1}{16}$ in. traverse; and $\frac{1}{16}$ in., $\frac{1}{8}$ in., $\frac{3}{16}$ in., $\frac{1}{4}$ in., and $\frac{3}{8}$ in. cuts at $\frac{1}{8}$ in. traverse.

The results of these experiments are shown on Fig. 8. The lines are slightly curved upwards instead of being true straight lines passing through the zero of co-ordinates; but this is probably due to the tools becoming blunter as the trials proceeded; for they were made in the order of time enumerated above: the lightest first. It will be noticed that when the tool had failed with a cut $\frac{3}{8}$ in. by $\frac{1}{8}$ in., and had been re-ground, the same (intended) cut was made with a much lower observed cutting force. The conclusion from these trials is that the cutting force is proportional to the product of cut and traverse, and equals about 95 tons per sq. in. for the medium steel.

The other full-line curve is of a similar character, and gives for the same material a cutting stress of 115 tons per sq. in. The difference between these two values of the cutting stress tends to show that fine traverses take more power than coarse ones for the same area of cut. [This is what calculation would lead us to expect; for the forces required to produce crushing and

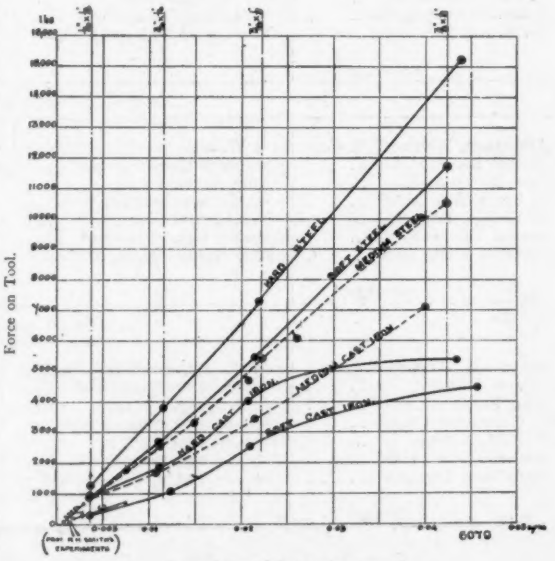


FIG. 7.—VARIATION OF CUTTING FORCE WITH AREA OF CUT FOR ALL MATERIALS USED. OBTAINED BY CALCULATION.

TABLE III.—

1 TOOL STEEL MAKER (Arranged alphabetically).	2 Name of Brand of Steel.	3 No. of Trial.	4 Intended Speed.	5&6 Intended Cut and Traverse.	7 Actual Speed.
			Object of Trial :—		
			Ft. per min	Inches.	Ft. per min
Armstrong, Whitworth & Co. ...	A. W. high-speed Tool Steel	139	50·0		52·5
Samuel Buckley	Bohler ❋ Rapid self-hard ...	143	55·0	$\frac{3}{16}$	59·5
John Brown & Co.	Atlas self-hard Steel	133	47·0	by	49·75
C. Cammell & Co.	Special self-hardening Steel ..	137	60·0	$\frac{1}{16}$	58·0
T. Firth & Sons	N.F.K. Speedicut	131	45·0		46·8
Samuel Osborn & Co.	Mushet high-speed Steel ...	141	50·0		56·2
Seebohm & Dieckstahl	New capital high-speed Steel	135	60·0		59·1
Average ...					54·0
			Object of Trial :—		
Armstrong, Whitworth & Co. ...	A. W. high-speed Tool Steel	140	40·0		40·0
Samuel Buckley	Bohler ❋ Rapid self-hard ...	144	40·0	$\frac{3}{16}$	41·2
John Brown & Co	Atlas self-hard Steel	134	45·0	by	42·5
C. Cammell & Co.	Special self-hardening Steel ..	138	40·0	$\frac{1}{16}$	40·5
T. Firth & Sons	N.F.K. Speedicut	132	40·0		40·6
Samuel Osborn & Co.	Mushet high-speed Steel ...	142	40·0		38·8
Seebohm & Dieckstahl	New capital high-speed Steel	136	45·0		43·5
Average ...					41·01
			Object of Trial :—		
Armstrong, Whitworth & Co. ...	A. W. high-speed Tool Steel	153	28·0		30·8
Samuel Buckley	Bohler ❋ Rapid self-hard ...	155	30·0	$\frac{3}{16}$	30·7
John Brown & Co.	Atlas self-hard Steel	145	35·0	by	31·9
C. Cammell & Co.	Special self-hardening Steel ..	149	30·0	$\frac{1}{8}$	32·6
T. Firth & Sons	N.F.K. Speedicut	157	28·0		30·0
Samuel Osborn & Co.	Mushet high-speed Steel ...	151	30·0		29·9
Seebohm & Dieckstahl	New capital high-speed Steel	147	25·0		26·8
Average ...					30·4
			Object of Trial :—		
Armstrong, Whitworth & Co. ...	A. W. high-speed Tool Steel	154	20·0		20·8
Samuel Buckley	Bohler ❋ Rapid self-hard ...	156	20·0	$\frac{3}{8}$	18·7
John Brown & Co.	Atlas self-hard Steel	146	22·0	by	20·0
C. Cammell & Co.	Special self-hardening Steel ..	150	20·0	$\frac{1}{8}$	20·0
T. Firth & Sons	N.F.K. Speedicut	158	20·0		20·0
Samuel Osborn & Co.	Mushet high-speed Steel ...	152	20·0		20·15
Seebohm & Dieckstahl	New capital high-speed Steel	148	17·0		17·6
Average ...					19·61

HARD STEEL.

8	9	10	11	12	13	14	15	16	17
Actual		Area of Section of Cut.	Duration of Trial.	Area Machined.		Weight removed.		Cause of Withdrawal.	Relative condition of tool after trial.
Cut.	Traverse.			Total.	Per min.	Total.	Per min.		
To obtain Maximum Cutting Speed.									
Inches.	Inches.	Sq. ins.	Minutes	Sq. feet.	Sq. feet.	Lbs.	Lbs.		
0·0635	0·0625	0·00397	30·0	8·2	0·273	21·75	0·725	Time up	1
0·066	0·0625	0·00412	29·33	9·089	0·310	25·5	0·870	Tool failed	5
0·0625	0·0625	0·00390	30·0	7·7	0·29	20·25	0·675	Time up	1
0·058	0·0625	0·00362	19·066	5·75	0·302	14·75	0·780	Tool failed	5
0·0525	0·0625	0·00328	30·0	7·20	0·240	16·25	0·542	Time up	1
0·0610	0·0625	0·00381	30·0	8·76	0·292	21·0	0·700	do.	4
0·056	0·0625	0·00350	21·75	6·69	0·308	15·5	0·713	Tool failed	5
		0·00374							
To obtain Maximum Cutting Speed.									
0·1905	0·0625	0·0119	30·0	6·25	0·208	48·0	1·600	Time up	3
0·1985	0·0625	0·0124	30·0	6·44	0·214	51·25	1·708	do.	1
0·192	0·0625	0·0120	6·916	1·55	0·222	12·0	1·730	Tool failed	4
0·188	0·0625	0·01173	19·6	4·14	0·211	32·75	1·630	do.	4
0·1875	0·0625	0·0117	30·0	6·35	0·212	48·75	1.625	Time up	1
0·1873	0·0625	0·0117	23·066	4·66	0·202	36·0	1·560	Tool failed	4
0·1855	0·0625	0·0116	12·25	2·75	0·226	20·25	1·650	do.	4
		0·01186							
To Machine Maximum Area of Surface per minute.									
0·175	0·125	0·0219	30·0	9·6	0·32	69·0	2·300	Time up	2
0·1875	0·125	0·0234	16·916	5·042	0·32	41·25	2·450	Tool failed	2
0·1872	0·125	0·0234	6·8	2·260	0·333	15·5	2·280	do.	2
0·1830	0·125	0·0229	24·47	8·330	0·34	60·5	2·475	do.	1
0·181	0·125	0·02265	10·0	3·130	0·313	21·75	2·175	do.	2
0·184	0·125	0·0230	18·85	5·850	0·311	44·75	2·380	do.	2
0·196	0·125	0·0245	11·166	3·100	0·280	23·0	2·070	do.	2
		0·0231							
To Remove Maximum Weight per minute.									
0·362	0·125	0·0452	30·0	6·500	0·2166	92·75	3·092	Time up	2
0·371	0·125	0·0464	30·0	5·850	0·1950	90·75	3·025	do.	2
0·328	0·125	0·0410	30·0	6·230	0·2077	82·75	2·758	do.	5
0·353	0·125	0·0441	30·0	6·230	0·2077	90·0	3·000	do.	1
0·343	0·125	0·0429	30·0	6·230	0·2077	86·75	2·892	do.	5
0·362	0·125	0·0452	30·0	6·300	0·2100	93·0	3·100	do.	4
0·332	0·125	0·0415	30·0	5·500	0·1833	75·0	2·500	do.	7
		0.0438							

TABLE IV.–

1 TOOL STEEL MAKER (Arranged alphabetically).	2 Name of Brand of Steel.	3 No. of Trial.	4 Intended Speed.	5&6 Intended Cut and Traverse.	7 Actual Speed.
			Object of Trial :–		
			Ft. per min	Inches.	Ft. per min
Armstrong, Whitworth & Co....	A. W. high-speed Tool Steel	167	102·0		101·5
Samuel Buckley	Bohler ✻ Rapid self-hard ...	165	110·0		112·0
John Brown & Co.	Atlas self-hard Steel	171	100·0	$\frac{1}{16}$	107·0
C. Cammell & Co.	Special self-hardening Steel ..	161	108·0	by	109·0
T. Firth & Sons	N.F.K. Speedicut	170	106·0	$\frac{1}{16}$	107·0
Samuel Osborn & Co....	Mushet high-speed Steel ...	163	106·0		103·5
Seebohm & Dieckstahl	New capital high-speed Steel	159	104·7		103·5
Average ...					106·2
			Object of Trial :—		
Armstrong, Whitworth & Co....	A. W. high-speed Tool Steel	168	85·0		89·0
Samuel Buckley...	Bohler ✻ Rapid self-hard ...	166	80·0		80·2
John Brown & Co.	Atlas self-hard Steel	172	90·0	$\frac{1}{16}$	89·0
C. Cammell & Co.	Special self-hardening Steel ..	162	80·0	by	82·1
T. Firth & Sons	N.F.K. Speedicut	169	100·0	$\frac{1}{16}$	99·5
Samuel Osborn & Co.	Mushet high-speed Steel ...	164	86·0		84·7
Seebohm & Dieckstahl... ...	New capital high-speed Steel	160	71·3		71·0
Average ...					85·1
			Object of Trial :—		
Armstrong, Whitworth & Co....	A. W. high-speed Tool Steel	182	67·0		66·2
Samuel Buckley...	Bohler ✻ Rapid self-hard ...	177	61·0		62·0
John Brown & Co.	Atlas self-hard Steel	185	62·0	$\frac{3}{16}$	61·5
C. Cammell & Co.	Special self-hardening Steel ..	173	70·0	by	72·0
T. Firth & Sons	N.F.K. Speedicut	179	60·0	$\frac{1}{4}$	64·0
Samuel Osborn & Co.	Mushet high-speed Steel ...	175	55·0		58·2
Seebohm & Dieckstahl	New capital high-speed Steel	186	60·0		60·9
Average ...					63·5
			Object of Trial :—		
Armstrong, Whitworth & Co....	A. W. high-speed Tool Steel	183	55·0		55·5
Samuel Buckley...	Bohler ✻ Rapid self-hard ...	178	51·0		49·0
John Brown & Co.	Atlas self-hard Steel	184	53·0	$\frac{3}{16}$	53·0
C. Cammell & Co.	Special self hardening Steel ..	174	43·0	by	43·8
T. Firth & Sons	N.F.K. Speedicut	180	50·0	$\frac{1}{4}$	53·2
Samuel Osborn & Co.	Mushet high-speed Steel ...	176	45·0		48·5
Seebohm & Dieckstahl	New capital high-speed Steel	187	52.25		52·25
Average ...					50·75

SOFT CAST IRON.

8	9	10	11	12	13	14	15	16	17
Actual		Area of Section of Cut.	Duration of Trial.	Area Machined.		Weight removed.		Cause of Withdrawal.	Relative condition of tool after trial.
Cut.	Traverse.			Total.	Per min.	Total.	Per min.		
To obtain Maximum Cutting Speed.									
Inches.	Inches.	Sq. ins.	Minutes	Sq. feet.	Sq. feet.	Lbs.	Lbs.		
0·0655	0·0625	0·00409	30·0	15·8	0·527	37·25	1·242	Time up	1
0·060	0·0625	9·00375	20·5	11·9	0·582	25·5	1·24	Tool failed	5
0·0635	0·0625	0·00397	30·0	16·75	0·558	37·75	1·258	Time up	4
0·0625	0·0625	0·0039	30·0	17·02	0·567	39·0	1·300	do.	1
0·064	0·0625	0·004	14·916	8·38	0·558	19·0	1·275	Tool failed	5
0·019	0·0625	0·00118	16·0	8·58	0·539	11·75	0·735	do.	7
0·063	0·0625	0·00394	30·0	16·18	0·539	38·0	1·267	Time up	1
		0·00355							
To obtain Maximum Cutting Speed.									
0·1975	0·0625	0·0124	30·0	13·9	0·463	95·0	3·167	Time up	4
0·197	0·0625	0·0123	9·0	3·75	0·417	26·0	2·889	Tool failed	6
0·186	0·0625	0·0116	1·333	0·615	0·463	3·0	2·29	do.	7
0·196	0·0625	0·01225	30·0	12.8	0·427	91·75	3·058	Time up	1
0·1975	0·0625	0·0124	30·0	15·55	0·518	108·5	3·602	do.	4
0·194	0·0625	0·0121	30·0	13·22	0·441	92·25	3·175	do.	1
0·198	0·0625	0·0124	30·0	11·1	0·370	76·25	2·542	do.	1
		0·01221							
To Machine Maximum Area of Surface per minute.									
0·171	0·125	0·0214	30·0	20·7	0·69	131·5	4·383	Time up	4
0·170	0·125	0·0213	26·816	17·3	0·646	116·25	4·330	Tool failed	3
0·151	0·125	0·0189	25·016	16·01	0·64	98·5	3·94	do.	4
0·126	0·125	0·01575	30·0	22·5	0·75	93·0	3·100	Time up	4
0·1825	0·125	0·0228	30·0	20·01	0·667	126·25	4·208	do.	2
0·185	0·125	0·0237	30·0	18·2	0·607	125·25	4·175	do.	1
0·171	0·125	0·0214	21·0	13·36	0·636	86·75	4·125	Tool failed	4
		0·02075							
To Remove Maximum Weight per minute.									
0·366	0·125	0·0459	30·0	17·35	0·578	223·75	7·458	Time up	6
0·379	0·125	0·0474	30·0	15·36	0·512	215·5	7·183	do.	1
0·336	0·125	0·042	30·0	16·6	0·552	209·0	6·967	do.	6
0·368	0·125	0·046	30·0	13·7	0·457	186·0	6·200	do.	1
0·37	0·125	0·0462	30·0	16·62	0·554	220·0	7·330	do.	1
0·369	0·125	0·046	30·0	15·2	0·507	201·0	6·700	do.	1
0·364	0·125	0·0455	30·0	16·4	0·547	219·75	7·325	do.	5
		0.0456							

TABLE V.—

1 TOOL STEEL MAKER (Arranged alphabetically).	2 Name of Brand of Steel.	3 No. of Trial	4 Intended Speed.	5 & 6 Intended Cut and Traverse.	7 Actual Speed.
			Object of Trial :—		
			Ft. per min	Inches.	Ft. per min
Armstrong, Whitworth & Co. ...	A. W. high-speed Tool Steel	52	50·0		50·7
Samuel Buckley...	Bohler ✻ Rapid self-hard ...	42	50·0		51·8
John Brown & Co.	Atlas self-hard Steel	50	65·0	$\frac{1}{16}$	62·0
C. Cammell & Co.	Special self-hardening Steel ..	54	70·0	by	68·5
T. Firth & Sons	N.F.K. Speedicut	46	55·0	$\frac{1}{16}$	56·88
Samuel Osborn & Co.	Mushet high-speed Steel ...	44	70·0		69·0
Seebohm & Dieckstahl	New capital high-speed Steel	48	60·0		59·7
Average ...					59·8
			Object of Trial :—		
Armstrong, Whitworth & Co. ...	A. W. high-speed Tool Steel	53	40·0		40·3
Samuel Buckley	Bohler ✻ Rapid self-hard ...	43	50·0		49·0
John Brown & Co.	Atlas self-hard Steel	51	50·0	$\frac{1}{16}$	48·8
C. Cammell & Co.	Special self-hardening Steel ..	55	50·0	by	50·2
T. Firth & Sons	N.F.K. Speedicut	47	45·0	$\frac{1}{16}$	44·24
Samuel Osborn & Co.	Mushet high-speed Steel ...	45	50·0		49·8
Seebohm & Dieckstahl	New capital high-speed Steel	49	50·0		51·2
Average ...					47·65
			Object of Trial :—		
Armstrong, Whitworth & Co. ...	A. W. high-speed Tool Steel	58			33·1
Samuel Buckley...	Bohler ✻ Rapid self-hard ...	64	50·0		50·0
John Brown & Co.	Atlas self-hard Steel	60	33·0	$\frac{1}{16}$	30·3
C. Cammell & Co.	Special self-hardening Steel ..	56	30·0	by	31·9
T. Firth & Sons	N.F.K. Speedicut	62	30·0	$\frac{1}{8}$	34·4
Samuel Osborn & Co.	Mushet high-speed Steel ..	68	35·0		34·4
Seebohm & Dieckstahl	New capital high-speed Steel	66	40·0		36·6
Average ...					35·8
			Object of Trial :—		
Armstrong, Whitworth & Co. ...	A. W. high-speed Tool Steel	59	28·0		27·7
Samuel Buckley	Bohler ✻ Rapid self-hard ...	65	25·0		24·35
John Brown & Co.	Atlas self-hard Steel	61	25·0	$\frac{3}{8}$	25·2
C. Cammell & Co.	Special self-hardening Steel ..	57	25·0	by	25·6
T. Firth & Sons	N.F.K. Speedicut	63	20·0	$\frac{1}{8}$	22·0
Samuel Osborn & Co.	Mushet high-speed Steel ...	69	25·0		25·1
Seebohm & Dieckstahl... ...	New capital high-speed Steel	67	28·0		25·4
Average ...					25·0

MEDIUM CAST IRON.

8	9	10	11	12	13	14	15	16	17
Actual		Area of Section Cut.	Duration of Trial.	Area Machined.		Weight removed.		Cause of Withdrawal.	Relative condition of tools after trial.
Cut.	Traverse.			Total.	Per min.	Total.	Per min.		
To obtain Maximum Cutting Speed.									
Inches.	Inches.	Sq. ins.	Minutes	Sq. feet.	Sq feet.	Lbs.	Lbs.		
0·0610	0·0610	0·00381	30·0	7·95	0·265	18·25	0·608	Time up	2
0·059	0·0625	0·00368	30·0	8·091	0·269	19·25	0·642	do.	1
0·0465	0·0624	0·0029	13·0	4·3	0·33	7·0	0·54	Tool failed	4
0·056	0·0625	0·00350	10·3	3·68	0·358	8·5	0·825	do.	3
0·063	0·0625	0·00393	19·75	5·78	0·292	13·0	0·658	do.	4
0·050	0·0624	0·00313	1·83	0·702	0·382	1·0	0·545	do.	4
0·053	0·0624	0·00331	30·0	9·26	0·308	20·75	0·69	Time up	4
		0·00347							
To obtain Maximum Cutting Speed.									
0·159	0·062	0·00986	30·0	6·22	0·207	38·5	1·28	Time up	2
0·1840	0·0623	0·0115	30·0	7·618	0·254	52·0	1·73	do.	1
0·176	0·0625	0·0110	1·0	0·24	0·24	1·75	1·75	Tool failed	2
0·174	0·062	0·0109	5·66	1·42	0·25	9·5	1·68	do.	2
0·1685	0·0625	0·0105	8·41	1·94	0·230	12·0	1·42	do.	2
0·1560	0·0624	0·0097	8·1	2·08	0·256	12·75	1·575	do.	2
0·173	0·062	0·0108	17·21	4·54	0·26	30·75	1·77	do.	2
		0·0106							
To Machine Maximum Area of Surface per minute.									
0·1815	0·125	0·0227	30·0	10·1	0·335	67·0	2·23	Time up	1
0·1770	0·125	0·0221	1·41	0·726	0·51	4·25	3·0	Tool failed	7
0·1625	0·125	0·0203	10·0	3·27	0·327	18·5	1·85	do.	4
0·140	0·123	0·0175	30·0	9·8	0·327	57·25	1·908	Time up	2
0·175	0·125	0·0219	26·8	9·05	0·337	58·0	2·16	Tool failed	4
0·178	0·125	0·0223	17·33	6·12	0·352	40·75	2·34	do.	4
0·175	0·125	0·0219	12·0	4·57	0·38	28·0	2·33	do.	2
		0·02124							
To Remove Maximum Weight per minute.									
0·298	0·125	0·0373	15·0	4·35	0·29	46·5	3·1	Tool failed	7
0·356	0·124	0·0446	30·0	7·47	0·249	99·5	3·32	Time up	1
0·281	0·124	0·0351	10 0	2·58	0·258	26·0	2·6	Tool failed	3
0·321	0·123	0·0401	7·25	1·92	0·264	21·75	3·0	do.	3
0·352	0·124	0·0440	30·0	6·83	0·227	88·5	2·95	Time up	1
0·326	0·125	0·0407	5·75	1·5	0·261	17·0	2·96	Tool failed	3
0·302	0·124	0·0377	9·0	2·51	0·279	23·75	2·64	do.	3
		0·0399							

TABLE VI.—

1 TOOL STEEL MAKER (Arranged alphabetically).	2 Name of Brand of Steel.	3 No. of Trial.	4 Intended Speed.	5&6 Intended Cut and Traverse.	7 Actual Speed.
			Object of Trial :—		
			Ft. per min	Inches.	Ft. per min
Armstrong, Whitworth & Co. ...	A. W. high-speed Tool Steel	107	32·0		36·4
Samuel Buckley...	Bohler ❋ Rapid self-hard ...	190	35·0		31·1
John Brown & Co.	Atlas self-hard Steel	113	35·40	$\frac{1}{16}$	38·5
C. Cammell & Co.	Special self-hardening Steel ..	109	35·0	by	38·6
T. Firth & Sons	N.F.K. Speedicut	117	30·0	$\frac{1}{16}$	36·0
Samuel Osborn & Co.	Mushet high-speed Steel ...	121	37·0		37·5
Seebohm & Dieckstahl	New capital high-speed Steel	111	40·0		38·4
Average ...					36·65
			Object of Trial :—		
Armstrong, Whitworth & Co. ...	A. W. high-speed Tool Steel	108	30·0		30·3
Samuel Buckley...	Bohler ❋ Rapid self-hard ...	191	28·0		26·7
John Brown & Co.	Atlas self-hard Steel	114	33·0	$\frac{3}{16}$	30·5
C. Cammell & Co.	Special self-hardening Steel ..	110	30·0	by	31·9
T. Firth & Sons	N.F.K. Speedicut	120	30·0	$\frac{1}{16}$	31·8
Samuel Osborn & Co.	Mushet high-speed Steel ...	122	30·0		29·5
Seebohm & Dieckstahl	New capital high-speed Steel	112	30·0		30·1
Average ...					30·1
			Object of Trial :—		
Armstrong, Whitworth & Co. ...	A. W. high-speed Tool Steel	125	20·0		21·0
Samuel Buckley...	Bohler ❋ Rapid self-hard ..	189	22·0		20·8
John Brown & Co.	Atlas self-hard Steel	115	22·0	$\frac{5}{16}$	20·2
C. Cammell & Co.	Special self-hardening Steel ..	129	25·0	by	25·0
T. Firth & Sons	N.F.K. Speedicut	118	20·25	$\frac{1}{8}$	24·7
Samuel Osborn & Co.	Mushet high-speed Steel ...	124	20·0		20·1
Seebohm & Dieckstahl	New capital high-speed Steel	127	25·0		24·75
Average ...					22·36
			Object of Trial :—		
Armstrong, Whitworth & Co. ...	A. W. high-speed Tool Steel	126	18·0		18·0
Samuel Buckley...	Bohler ❋ Rapid self-hard ...	188	18·0		18·45
John Brown & Co.	Atlas self-hard Steel	116	18·20	$\frac{3}{8}$	17·2
C. Cammell & Co.	Special self-hardening Steel ..	130	20·0	by	18·1
T. Firth & Sons	N.F.K. Speedicut	119	20·0	$\frac{1}{8}$	22·0
Samuel Osborn & Co.	Mushet high-speed Steel ...	123	22·0		...
Seebohm & Dieckstahl	New capital high-speed Steel	128	20·0		19·5
Average ...					18·88

HARD CAST IRON.

8	9	10	11	12	13	14	15	16	17
Actual		Area of Section of Cut.	Duration of Trial.	Area Machined.		Weight removed.		Cause of Withdrawal.	Relative condition of tool after trial.
Cut.	Traverse.			Total.	Per min.	Total.	Per min.		
To obtain Maximum Cutting Speed.									
Inches.	Inches.	Sq. ins.	Minutes	Sq. feet.	Sq. feet.	Lbs.	Lbs.		
0·057	0·0625	0·00369	30·0	5·700	0·1900	12·875	0·4292	Time up	1
0·063	0·0625	0·00398	13·25	2·15	0·1610	4·75	0·3580	Tool failed	6
0·0600	0·0625	0·00375	30·0	6·0	0·2000	14·5	0·4833	Time up	4
0·0575	0·0625	0·00359	30·0	6·03	0·2010	14·0	0·4666	do.	1
0·0625	0·0625	0·00390	30·0	5·62	0·1870	13·25	0·4417	do.	4
0·058	0·0625	0·00343	30·0	5·85	0·195	12·875	0·4292	do.	6
0·0605	0·0625	0·00378	30·0	5·98	0·1993	14·0	0·4667	do.	1
		0·00373							
To obtain Maximum Cutting Speed.									
0·188	0·0625	0·01173	30·0	4·73	0·1577	33·5	1·117	Time up	1
0·168	0·0625	0·01048	30·0	4·175	0·1392	28·0	0·933	do.	2
0·162	0·0625	0·01010	30·0	4·76	0·1587	28·75	0·958	do.	6
0·1875	0·0625	0·01173	30·0	5·0	0·1667	35·5	1·183	do.	2
0·1850	0·0625	0·01155	13·0	2·15	0·1660	14·75	1·136	Tool failed	6
0·1700	0·0625	0·01061	30·0	4·6	0·1533	30·0	1·000	Time up	2
0·1790	0·0625	0·01119	30·0	4·7	0·1567	31·25	1·042	do.	1
		0·01105							
To Machine Maximum Area of Surface per minute.									
0·1875	0·125	0·02345	60·0	13·15	0·219	88·0	1·467	Time up	1
0·1380	0·125	0·01725	60·0	13·06	0·2177	63·25	1·054	do.	5
0·1725	0·125	0·02155	60·0	12·6	0·2100	81·5	1·358	do.	2
0·162	0·125	0·02025	60·0	15·6	0·2600	85·25	1·421	do.	3
0·169	0·125	0·02112	60·0	15·42	0·257	97·25	1·621	do.	7
0·174	0·125	0·02175	17·0	3·73	0·219	23·125	1·360	Tool failed	5
0·153	0·125	0·01912	60·0	15·5	0·2580	85·75	1·429	Time up	3
		0·02064							
To Remove Maximum Weight per minute.									
0·365	0·125	0·0457	30·0	5·65	0·188	76·0	2·533	Time up	2
0·290	0·125	0·0363	30·0	5·78	0·193	61·25	2·417	do.	4
0·358	0·125	0·0448	30·0	5·38	0·179	71·75	2·392	do.	2
0·341	0·125	0·0426	30·0	5·65	0·1883	76·25	2·542	do.	1
0·367	0·125	0·0459	30·0	6·9	0·230	96·0	3·2	do.	4
...	0·125	...	...	...	...	...	...	Tool failed	7
0·353	0·125	0·0441	30·0	6·1	0·203	79·5	2·650	Time up	4
		0.0432							

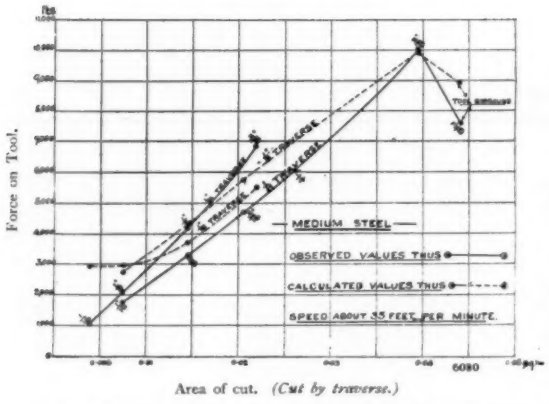


FIG. 8.—VARIATION OF CUTTING FORCE WITH AREA OF CUT OBTAINED FROM EXPERIMENTS WITH DYNAMOMETER ON LATHE. TRAVERSE CONSTANT.

deformation of the shaving ought to increase with the depth of the cut.]

On Fig. 7 have been plotted the values of the cutting force obtained in the experiments of Prof. R. H. Smith, which are graphed in his work, "Cutting Tools."

In the endeavour to find the law according to which the cutting stress varies with the speed, the average value of the cutting force for each group of eight tests (made with eight different steels upon a given material with approximately the same feed and cut, and the same speeds) was divided by the mean of the areas cut; and the average cutting stresses so obtained, twenty-four in number, were plotted as ordinates on a base of speed, as shown by Fig. 9.

The uncertainty in the determination of the values of the cutting stresses by means of the volt- and ammeter readings, especially at the lighter cuts, *i.e.* the higher speeds, already referred to, is made more clearly manifest by this diagram.

If the values for the very lightest cuts ($\frac{1}{16}$ by $\frac{1}{16}$) be entirely ignored, then in the case of steel the cutting stress would appear to diminish somewhat as the speed increases. In the case of cast-iron nothing can be inferred but a certain approximation to constancy of the cutting stress, and an independence of speed. The speed variation in the latter case is of a much more limited range, however, than for the steels.

On the whole, the verdict appears to be that the cutting stress has not been shown by these experiments to vary very much with speed. For cast-iron this stress may be specified as follows:—

For soft cast-iron ...	51	tons per sq. in.
For medium cast-iron	84	,, ,,
For hard cast-iron ...	82	,, ,,

A few experiments were made with the lathe-tool dynamometer in regard to this question of variation of cutting force with speed. The first series were made with a constant cut of $\frac{3}{16}$ in. by $\frac{1}{8}$ in. at speeds varying from 30 to 90 ft. per min. upon medium hard steel. The results are plotted at *a a* on Fig. 9. Unfortunately they are not so reliable as could be wished, as some of the observers (students) were not very good.

A second series is of a more trustworthy character. They were made upon medium cast-iron, with a cut $\frac{3}{16}$ in. by $\frac{1}{16}$ in., at speeds from 10 to 60 ft. per min. These trials are also plotted on Fig. 9, a fair curve, *b b*, being drawn through them. They show a fairly regular diminution of the cutting stress as the speed of cutting increases.

(To be concluded.)

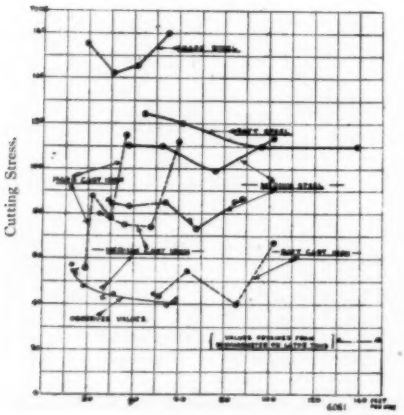


FIG. 9.—VARIATION OF CUTTING STRESS WITH CUTTING SPEED. CALCULATED FROM CURRENT MEASUREMENTS.

NOTES ON LOCOMOTIVE AND RAILWAY ENGINEERING.

High Capacity Wagons on the Great Northern Railway.

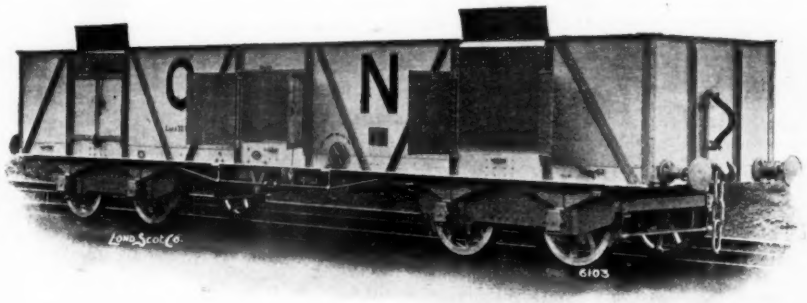
THE advantages attending the use of high-capacity goods wagons have long been recognised by the authorities of the Great Northern Railway, upon which line a large number of these vehicles are to be found.

One of the 30-ton carrying capacity bogie wagons belonging to the company is illustrated herewith. These wagons are constructed of steel throughout, and are equipped with the vacuum brake, a separate cylinder being provided for each bogie, whilst in addition a screw brake, which can be applied from either side, is also fitted. The inside dimensions are 38 ft. 3⅜ ins. by 7ft. 6 ins. by 4ft. 2¼ ins., and unlike many of the so-called high-capacity wagons, principally of American construction, these are fully capable of carrying the specified quantity of coal. A special feature of the wagons is the provision of a removable hinged flat above each of the six double-folding side doors, thus enabling a man to wheel a barrow into the wagon, without obstruction, from a loading bank. The builders, Messrs. Hurst, Nelson & Co., Ltd., of Glasgow, and Chatsworth near Chesterfield, state that they tested one of these wagons with a load of 50 tons, or 20 tons in excess of that for which it was built, and that under this load the deflection of the underframe was hardly perceptible. The Great Northern Railway officials have also subjected the wagon to a load test of 40 tons without any injury whatever resulting. The workmanship throughout is of the highest possible order, and reflects great credit upon the builders, whom, it may be added, have a large number of similar capacity wagons on order for the Caledonian Railway Company.

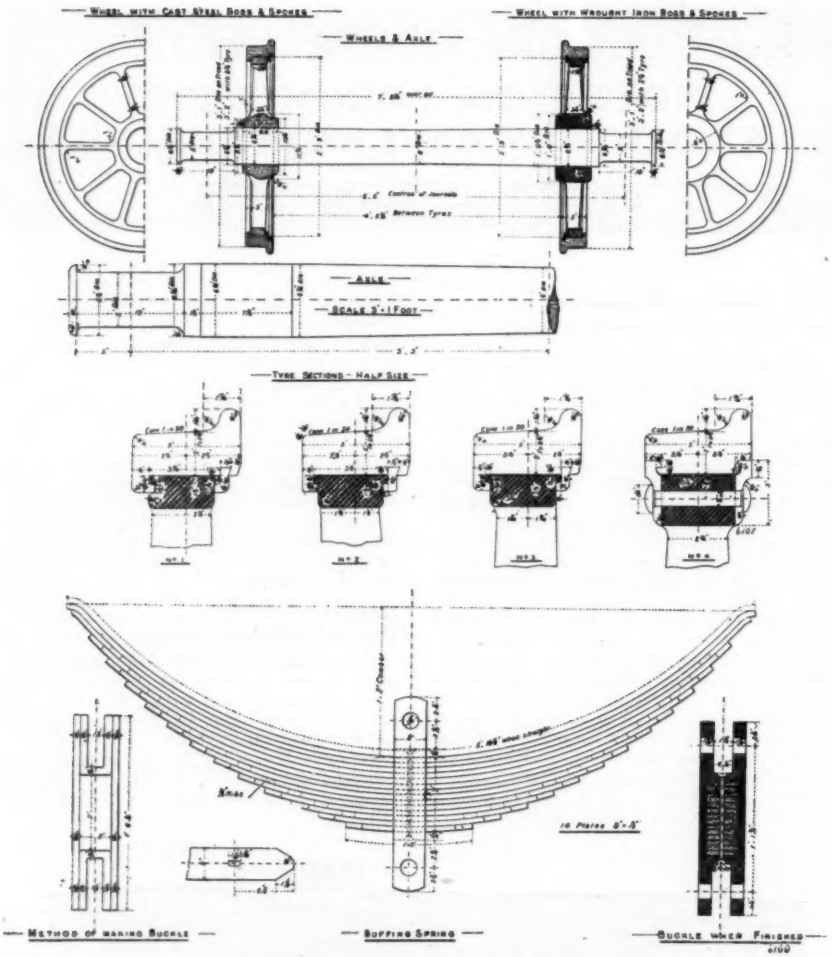
Details of Private Owner's 20-ton Wagons.

Continuing this subject from last month, some of the drawings of standard details then referred to are shown herewith, and extracts from the specifications which accompany them are as follows :—

TYRES.—These are to be of Bessemer or Siemens steel, and to be subjected to the tests set forth in clause 20, which reads thus :—



30-TON BOGIE WAGON CONSTRUCTED FOR THE GREAT NORTHERN RAILWAY BY MESSRS. HURST, NELSON AND CO., MOTHERWELL.



DETAILS OF PRIVATE OWNER'S 20-TON WAGON.

Testing of Steel Tyres and Axles.

(*a*) No tyre to have a diameter of less than 3 ft. 1 in. on tread, and each is to be guaranteed to stand the following tests without reheating or any other manipulation whatever, either of the tyre selected for testing, or of any portion cut therefrom, to furnish the tensile test-piece.

Failing Weight Test.

(*b*) The tyre, placed in a running position on a solid foundation, and subjected to repeated blows of a 20-cwt. tup, falling from a height of 10 ft., 15 ft., 20 ft., 25 ft., and upwards, must deflect 1 in. for every 8 ins. of the internal diameter without fracture—the blows to be continued until the tyre is doubled up or broken.

(*c*) A test-piece, half a square inch area, machined cold from each tyre, which has been subjected to the falling weight test, must have an ultimate tensile strength and

elongation, as follows :—Ultimate tensile strength, not less than 35 tons per sq. in.; elongation, measured over parallel length of 3 ins., not less than 25 per cent., or over 2 ins., not less than 30 per cent.

Clause 20 also provides other conditions, (*d*), (*e*), and (*f*), relating to discretionary powers extended to inspectors with regard to the results obtained during progress of the above tests. Continuing.—Each axle has to be guaranteed to stand the following tests.

(*g*) *Drop Test.*—Five blows without fracture from a weight of 2,000 lbs. falling from a height of 30 ft. upon the axle placed upon bearings 3 ft. 6 ins. apart, the axle to be turned after first and third blows ; after being tested, the axle to be broken.

(*h*) *Tensile Test.*—A test-piece, cut from any part of the axles tested, or from the ends left on the forgings, to give an ultimate strength of not less than 30 tons, nor more than 35 tons per sq. in., with 25 per cent. elongation, measured over a parallel length of 3 ins., having an area of half a square inch.

(*i*) *Cold Bend Test.*—A bar 9 ins. long and 1¼ in. square, $\frac{1}{16}$-in. radius at the corners, to be bent through 90 degs. round a bar 2½ ins. diameter, and the ends brought together without fracture. Sections of clause 20 (*j*), (*k*), (*l*), and (*m*) again refer to the rejective rights of the inspector.

Passing on to the tests applied to wrought-iron axles, clause 21 provides :—

(*a*) *Drop Test.*—Five blows without fracture from a weight of 2.000 lbs. falling from a height of 30 ft. upon the axle, placed upon bearings 3 ft. 6 ins. apart ; the axle to be turned after first and third blows, and broken at the conclusion of the tests.

(*b*) *Tensile Test.*—A test-piece to be cut from any part of the axles tested, or from the ends left on the forgings, to give an ultimate strength of not less than 22 tons per sq. in., with 20 per cent. elongation, measured over a parallel length of 8 ins., having an area of half a square inch.

(*c*) *Cold Bend Test.*—A bar 9 ins. long and 1¼ in. square, $\frac{1}{16}$-in. radius at the corners, to be bent through 90 degs. round a bar 2¼ ins. diameter, and the ends brought together without fracture. Regarding the construction of the buffing springs (illustrated): these are to be laminated, and to consist of fourteen plates of 3 ins. by ½-in. steel, and to be tested at the makers' works by an inspector. The spring buckle must be made of forged iron or steel, in accordance with the method shown in the drawing. Further illustrations and particulars will be given of other details of construction, and the tests to which they are subjected before being accepted by the railway company's superintendent or his inspector.

Extension of the Railway Motor Coach System.

Following upon the example set by the London and South Western Railway Co., the Great Western authorities recently placed in service some steam motor coaches. These run between Chalford and Stonehouse in Gloucestershire, and serve a district in which railway facilities, so far as local point-to-point traffic is concerned, have hitherto been very inadequate for the public need. This state of affairs, however, has been remedied by the introduction of the vehicles under notice ; and as the traffic is conducted in a similar manner to that which prevails on electric tramway systems—viz., with regularly appointed stopping places (other than at stations)—the convenience of the new service is thoroughly felt and appreciated by those who reside in the districts affected.

STEAM MOTOR COACH FOR THE GREAT WESTERN RAILWAY.

The coaches were built at the railway company's works at Swindon, from the designs of Mr. G. J. Churchward, M.Inst.C.E., Locomotive Superintendent, to whom the writer is indebted for the photograph reproduced,

and which shows No. 1, the first coach to be built. A good idea of the external appearance and the general arrangement of the car may be gathered from the illustration. The cars are 57 ft. $\frac{3}{4}$ in. in length by 8 ft. $6\frac{3}{4}$ ins. wide, and are divided into three compartments as follows:—Passenger 39 ft. long, motor 12 ft. 9 ins. long, and vestibule 4 ft. long. The underframes are of steel, and are carried on two suspension-hung bogies. The total wheel-base is 45 ft. 6 ins.; that of the motor bogie being 8 ft., and the carriage bogie 8 ft. 6 ins.

The cylinders are 12 ins. diameter by 16 ins. stroke, fixed horizontally on the frame of the bogie, the wheels of which are 3 ft. 8 ins. diameter, and coupled together. The valve motion is of the Walschaert pattern, actuating balanced slide valves placed on top of the cylinders. Steam is supplied by a vertical boiler with cone top 4 ft. 6 ins. diameter, and containing 477 tubes $1\frac{1}{8}$ in. diameter. The working pressure is 180 lbs. per square inch. The heating surface is: Tubes 625·58 sq. ft., and firebox 44·34 sq. ft., the total therefore being 669·92 sq. ft., and the grate area is 11·48 sq. ft. The water tank is placed below the coach, and has a capacity of 450 gallons.

The coach will carry 52 passengers and a reasonable quantity of luggage, The engines can be operated from either end. Both hand and vacuum brakes are provided, acting on all the eight wheels; these may also be applied from either end of the vehicle. Little doubt can exist that the introduction of similar cars on other railways will follow the inauguration of the existing services with equally beneficial and satisfactory results.

The Great Western Railway French Compound.

The general design and principal dimensions of this locomotive may be gathered from the accompanying diagram.

As anticipated, it is practically identical with the compound engines constructed at the Belfort Works for the Nord and other French railways, and differs therefrom merely in some matters of detail.

The claims made on behalf of the system of compounding which is employed, and the principal features incorporated in the design, were set forth in these notes in the September number when the views and opinions of M. A. G. de Glehn, the originator of the principle involved, were presented. The engine has been appropriately named "La France;" and although nothing has transpired at the time of writing with regard to its performances in actual working, it almost goes without saying that the satisfactory results obtained across the channel with this type of engine will be repeated here. M. de Glehn, as an Englishman himself, will no doubt be highly interested in the achievements of the engine in this country, and although it is hardly likely that a second order from the same railway company would be sent to Belfort, whatever the outcome of the early trials may be, the designer and builders will have every reason to be satisfied if the anticipated results duly come about.

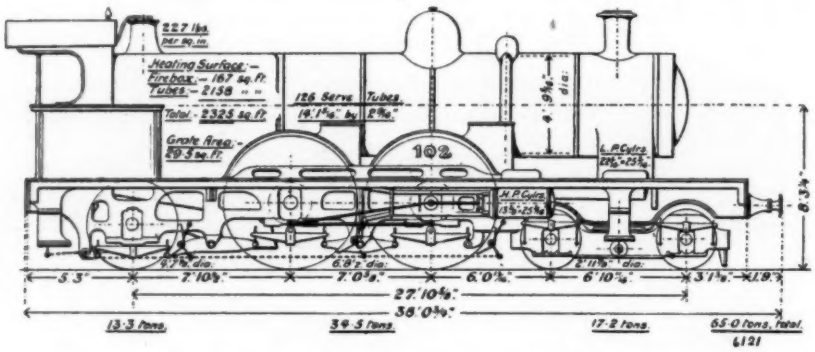


DIAGRAM OF THE DE GLEHN COMPOUND NO. 102, "LA FRANCE," GREAT WESTERN RAILWAY.

British Locomotive Exports in 1903.

The returns for the period extending over nine months—viz., from January 1st to

September 30th, 1903—in the locomotive export trade of this country were on the whole satisfactory, as compared with the corresponding period of 1902; they showed an advance of £91,071 sterling.

The supply to India fell off to the extent of £171,198, but this loss was largely compensated for by an advance in the value of the exports to British South Africa, which exceeded those of 1902 by no less than £141,698. This satisfactory result is doubtless owing mostly to the cessation of hostilities, and a strong trade may be looked for from that direction, which it is to be hoped British manufacturers will secure, and do all in their power to foster.

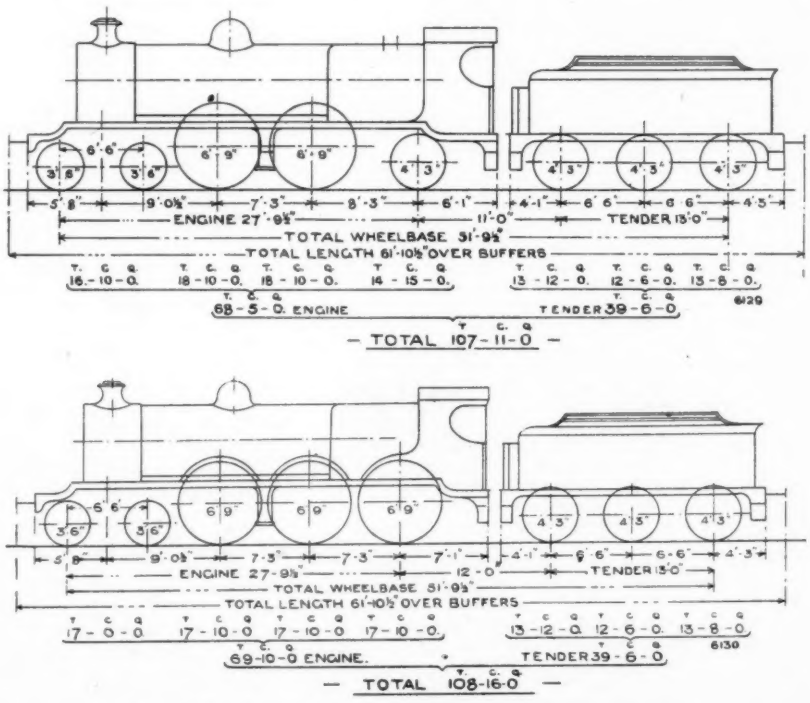
The figures representing locomotive exports to British Colonies for the first nine months of 1903, 1902, and 1901, were as follows:—

	1903	1902	1901
	£	£	£
British South Africa	460,778	319,080	179,298
British India ...	437,894	609,092	382,094
Australasia ...	321,659	287,897	274,762

British locomotives exported to South America during the same time were valued at £163,613, as compared with £98,281 in the corresponding period of 1902. This also represents a substantial advance, and is very satisfactory.

Great Central Accelerations.

Relying to correspondents who have intimated their desire to know something of the running of the "Sheffield Special"—viz. the 3.25 p.m. express from Marylebone to Sheffield since the accelerated schedule came into force—the writer recently travelled upon the engine of this train, by courteous permission of Mr. J. G. Robinson, M.Inst.C.E., the company's chief mechanical engineer, and on that occasion the run was performed in 2 hrs. 57 mins., or three minutes less than the time allowed. The usual slacks at Aylesbury and Quainton Road; at Leicester for slipping a coach; and through Nottingham (Victoria) station, were supplemented by two somewhat serious permanent way



DIAGRAMS OF THE NEW 4-4-2 AND 4-6-0 TYPES OF GREAT CENTRAL LOCOMOTIVES.

renewal slacks, so that the general character of the work performed was of a very high order indeed, the total distance of 164¾ mls. being covered in 177 mins., including the delays referred to.

The engine, No. 1,035, one of Mr. Robinson's fine 6-ft. 9-in. class of the standard "1013" pattern—already illustrated in these Notes—was handled in the most skilful manner by the driver, George Turner, of Gorton, one of the most experienced enginemen in the company's employ.

The train arrived outside Sheffield station at 6.20 p.m., and but for the compulsory slowness of the approach thereto another minute would undoubtedly have been deducted from the net running time. As it was, however, the performance was a highly meritorious one.

The return train, viz., the 8.50 a.m. *ex* Sheffield, made the return journey in 3 hrs. 3 mins., having been delayed in the London district by one of the Metropolitan Company's expresses.

The writer is also indebted to Mr. Robinson for diagrams and chief particulars of the new 4-4-2 and 4-6-0 types of locomotives which he has designed for working the principal express services on the Great Central Railway. At the time of writing the engines were nearing completion, and were expected to be running trial trips before the end of the year. The diagrams are sufficient to show that, in general outline, the new designs are in strict accordance with Mr. Robinson's practice in previous engines, and the dimensions are also similar in many respects to the "1013" class of four-coupled express passenger locomotives. Two of the 4-4-2 engines and two of the 4-6-0 type are being put into service. There is a slight difference in the cylinder diameters, as will be noted, but in other respects both engines of either type are identical. The particulars are as follows:—

4-4-2 Engines.

Cylinders diameter (one engine)	19 ins. × 26 ins
,, ,, (other engine)	19½ ,, × 26 ,,
Working pressure (both engines)	180 lbs per sq. in.
Total heating surface ...	.. 1,911 sq. ft.
Grate area	26 ,,

4-6-0 Engines.

Cylinders diameter (one engine)	19 ins. × 26 ins.
,, ,, (other engine)	19½ ,, × 26 ,,
Working pressure (both engines)	180 lbs. per sq. in.
Total heating surface ...	... 1.911 sq. ft.
Grate area	26 ,,

Both types have outside cylinders.

MARINE ENGINEERING & SHIPBUILDING NOTES

North-East Coast District.

THE wages question continues to occupy a prominent place in shipbuilding and engineering circles on the north-east coast. Employers have given further notices of reductions to all classes of shipyard workers, whilst many of the engineering establishments are already working three-quarters time. The general tendency points to a satisfactory settlement to all parties involved. There is little doubt that orders for new tonnage are being withheld until the labour question is settled. Reduction in working expenses naturally means that the cost of new ships will be further reduced, so that there will be greater incentive to secure new tonnage in anticipation of better times coming.

A few new orders have recently been placed on the Tyne. The Royal Mail Steam Packet Co. have ordered three powerful cargo steamers from Sir W. G. Armstrong, Whitworth & Co. Messrs. Hawthorne, Leslie & Co., have obtained a contract to build three torpedo boat destroyers for the Admiralty, identical with those at present being completed at their yard. In contrast with the majority of engineering establishments, the Parson's Marine Steam Turbine Co. continues to show great activity. A further order for this type of engine has been received from the Allan line, who have contracted for another ship with Stephen & Sons, Linthouse, to be engined on this principle.

Wear shipbuilding is in a most depressed condition ; with the exception of Doxford & Co., and J. L. Thompson & Co., the remainder of the yards have few ships on the berths. Laing & Sons have booked an order for a steamer for the Quebec Steamship Co. The engines will be built by Geo. Clark & Co. Doxford & Co. have also booked orders for three additional steamers of their well-known turret type.

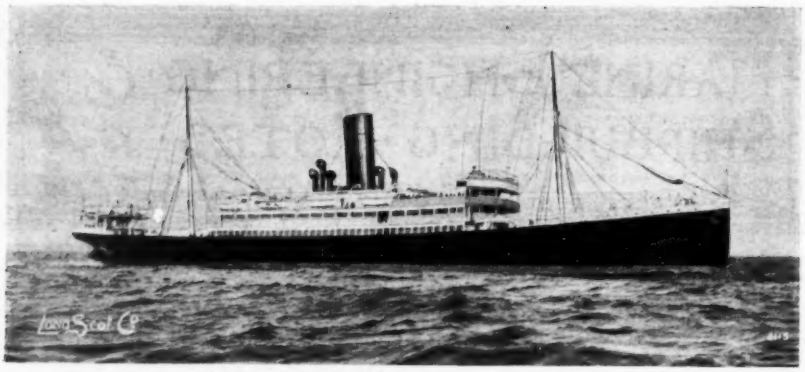
The shipbuilding industry on the Tees during the past year, though considerably behind previous years as regards tonnage output, has been responsible for a number of high-class cargo and passenger vessels. The firm of Sir Raylton Dixon & Co., of the Cleveland dockyard, whose reputation for the construction of these types of vessels is established throughout the shipping world, has added to an already long list a passenger and cargo boat, which equals if not surpasses any hitherto built on the Tees, for the Booth line of Royal Mail steamers which trade between Liverpool and London to Havre, Oporto, Lisbon, Madeira, and Brazilian ports.

This vessel has been designed to meet the requirements of this particular trade, with the result that the general impression one receives from an inspection is that the arrangements throughout will give unqualified satisfaction to those who for business or pleasure are called upon to pass the days of the voyage on this steamer.

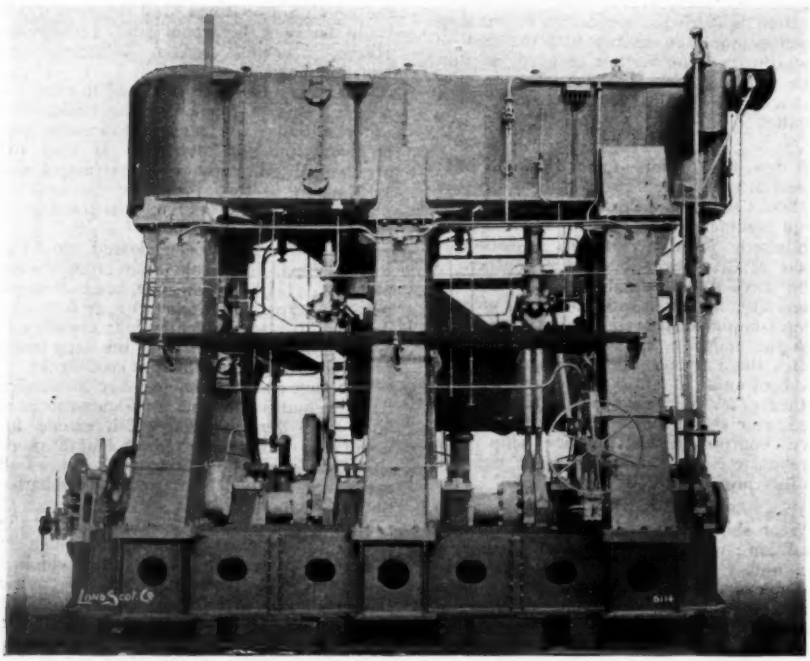
The *Ambrose* has been classed 100 A1 at Lloyd's, spar-deck rule with strengthened topsides. The dimensions are :—Length between perps., 375 ft.; breadth, 47 ft 6 ins.; depth, 29 ft. ; with a deadweight capacity of about 7,600 tons. She is on the deep-frame principle with two continuous steel decks.

The first-class passengers are accommodated in handsomely fitted up state-rooms in large steel deck houses, which extend for about two-fifths of the vessel's length amidships, on spar and bridge decks, in which are also contained lavatories, shower baths and hospitals.

Ample provision has been made for the social welfare of the passengers, which so materially affects the favour with which a vessel of this type is regarded. A music saloon and social hall has been arranged at the fore end of the house on the bridge deck, a view of which is seen on an accompanying illustration, whilst at the after end of the promenade deck there is a most commodious smoking room and bar. The dining saloon,



S.S. "AMBROSE." BUILT FOR THE BOOTH LINE OF STEAMERS BY MESSRS. SIR RAYLTON DIXON AND CO., CLEVELAND DOCKYARD.



5,000-I.H.P. DIRECT-ACTING SURFACE-CONDENSING TRIPLE-EXPANSION ENGINE FOR THE S.S. "AMBROSE." CONSTRUCTED BY THE NORTH EASTERN MARINE ENGINEERING CO., WALLSEND-ON-TYNE.

capable of seating 150 passengers, is placed on the main deck forward, and extends the full breadth of the vessel. Owing to the hot climate in which she is designed to trade, particular attention has been given to the ventilating arrangements by providing a large air hatch extending to the promenade deck, which is surmounted by a teak skylight; patent sidelights are fitted in the saloon which allow free access and egress of air, and two electric fans are placed at the fore end which ensure a constant current.

Access to the saloon is by means of handsome staircases from a house on the promenade deck or through the music saloon on the bridge deck and from the spar deck. The staircase leading from the promenade deck to the bridge deck is seen on the illustration, and the large opening immediately in front of it is the light and air shaft in the music saloon, which is surrounded by handsome pilasters, the effect being to give a lofty and airy appearance to the dining saloon.

A complete system of electric light and bells has been fitted by Messrs. Troup, Curtiss & Co., of London. The current for the electric light is provided by a dynamo at a tension of 100 volts.

The culinary department is on a most complete scale, and comprises a large galley placed on the spar deck considerably aft of the saloon, a bakery, butcher's shop, pantries and a refrigerating chamber of large capacity placed in the lower 'tween decks aft of the engine-room bulk-head, having ample provision for storing meat, fish, vegetables, wines, etc. The refrigerating plan is by the Haslam Foundry & Engineering Co., and consists of ammonia pipes led through the various compartments of the refrigerating chamber which is effectually insulated with charcoal.

S.S. "AMBROSE": VIEW OF THE MAIN STAIRCASE.

Special rooms for passengers' luggage and mails are arranged in the fore 'tween decks.

There is also accommodation provided for about 200 third-class passengers, in cubicles, in the after 'tween decks, with hospitals and wash-houses in the poop.

The cargo discharging gear consists of seven 7-in. by 10-in. steam winches by John Lynn & Co., of Sunderland, working four hatches, and so arranged as to deal with the cargo in a rapid manner.

The propelling machinery has been constructed by Messrs. the North Eastern Marine Engineering Co., at their Northumberland Engine Works, Wallsend-on-Tyne.

The engine is of the direct-acting surface-condensing triple-expansion type $\frac{31'' \times 51'' \times 83''}{54''}$, capable of developing about 5,000 i.h.p.

A cast-iron condenser of circular form is bolted to two of the back columns, and the air-pump, actuated by levers from the low-pressure cylinder, is of the Edward's patent type. A 15-in. centrifugal pump, by Messrs. Allen of Bedford, is fitted for circulating the water in the main condenser.

The working pressure of the machinery is 180 lbs. per sq. in. It is constructed to Lloyd's highest class and to the requirements of the Board of Trade for a passenger certificate.

The high-pressure and intermediate-pressure cylinders have large piston valves, and the low-pressure double-ported slide valves. The crank, thrust, tunnel, and propeller shafting is of hydraulic forged ingot steel throughout.

Four boilers, 16 ft. 6 ins. diameter by 11 ft. 7 ins. long, are fitted with Howden's system of forced draught, and in addition there is an auxiliary boiler 10 ft. by 10 ft., with natural draught, which may be utilised to supply steam to the main engines.

There are also a large number of auxiliaries, comprising main-feed pumps, ballast donkey, donkey feed, feed heater and cleaner, 35-ton evaporator, etc.

On the trial trip, which took place on the official course north of the Tyne, a mean speed of 15½ knots was attained with an i.h.p. of 4,510, the engines running at 80 revolutions per minute.

After having been thoroughly overhauled the vessel proceeded to Liverpool, *viâ* Scotland, with a large company on board. During the voyage she experienced heavy weather, which, however, only tended to confirm the builders' expectations that she would, under adverse conditions, prove a most seakindly boat.

* *

There can be little doubt, in the light of recent events, that oil in the near future will largely supersede coal as a steam-raising agent. For many years past the Wallsend Slipway & Engineering Co. have made a speciality of fitting steamers for the purpose of burning oil fuel, which has been attended with distinct success. The system which has hitherto been almost exclusively adopted is known as the Rusden & Eeles, of which the company have sole rights of manufacture. In this system the oil is sprayed by means of a steam jet. The drawback to this method is that the steam used in spraying is lost. This necessitates an expensive evaporating plant, so that the supply of boiler-feed water may be maintained.

Recently experiments were made by the Wallsend Slipway & Engineering Co., with a new method known as the Körting system, in which the oil is forced through a Körting sprayer by means of a pump, and sprayed directly into the furnace; hence the evaporating plant is dispensed with. Before reaching the burner the oil is carefully filtered, and heated to a temperature which depends upon the quantity of oil to be burned.

The boiler used for experimental purposes was of the ordinary marine type designed for forced draught, of which particulars are herewith given, together with tabulated results of the experiments :—

——	Coal Trial.	Natural Draught.	Closed Stokehold.
Duration of trial	6 hrs.	5 hrs.	Air pressure 1½" 4 hrs.
Class of fuel	Best Mickley picked.	Texas oil.	Texas oil.
Average steam pressure	113 lbs.	115 lbs.	105 lbs.
Average temperature of feed-water	55° Fahr.	80° Fahr.	107° Fahr.
Pressure of oil at burners	—	75 lbs.	140 lbs.
Temperature of oil at burners	—	240° Fahr.	110° Fahr.
Quantity of water evaporated per hr.	7,558 lbs.	7,756 lbs.	14,951 lbs.
,, oil burned per hr.	—	633·4 lbs.	1,222 lbs.
,, coal ,, ,, ...	974·3 lbs.	—	—
Water evaporated per lb. of oil and coal (respectively)	7·76 lbs.	12·24 lbs.	12·23 lbs.
,, ,, ,, from and at 212° Fahr.	9·31 lbs.	14·45 lbs.	14·06 lbs.
Quantity of water evaporated per hr. from and at 212° Fahr.	9,060 lbs.	9·52 lbs.	17,193 lbs.
Total quantity of ash	283 lbs.	—	—

COMPARISON OF OIL-BURNING TRIALS WITH THE KÖRTING PATENT BURNER AND COAL-BURNING TRIAL ON MARINE-TYPE BOILER:—

Mean diameter of boiler	12′ 6″
Mean length of boiler	11′ 0″
Number of furnaces	2
Inside diameter of furnaces ...	3′ 7″
Number of tubes	262*
External diameter of tubes ...	2½″
Total heating surface ...	1,695 sq. ft.
Grate area under coal	40 sq. ft.
Working pressure ...	120 lbs. per sq. in.

* All tubes fitted with retarders.

RESULTS OF TRIAL WITH KÖRTING PATENT BURNERS WITH INDUCED DRAUGHT ON MARINE-TYPE BOILER:—

Mean diameter of boiler	12′ 0″
Mean length of boiler	11′ 0″
Number of furnaces	2
Inside diameter of furnaces ...	3′ 9″
Total heating surface ...	1,200 sq. ft.
External diameter of tubes ...	3¼″

All tubes except two bottom rows fitted with retarders.

Duration of trial	6 hrs.
Class of fuel	Texas oil
Average steam pressure (gauge) ...	140 lbs.
,, temperature of feed-water	53° Fahr.
Vacuum at fan	1⅜″
,, furnace door	⅛″
,, ashpit ,, ...	⅜″
Temperature of air entering furnace (left)	250° Fahr.
Temperature of air entering furnace (right)	290° Fahr.
Temperature of gases at fan suction	465° Fahr.
Pressure of oil at burners	105 lbs.
Temperature ,, ,, ...	162° Fahr.
Total quantity of water evaporated,	65,500 lbs.
Quantity of water evaporated per hr.	10,917 lbs.
Total quantity of oil consumed ...	4,920 lbs.
Quantity of oil consumed per hr. .	820 lbs.
Pounds of water evaporated per lb. of oil (actual)	13·31 lbs.
Pounds of water evaporated per lb. of oil from and at 212° Fahr.	16·13 lbs.
Quantity of water evaporated per hr. from and at 212° Fahr. ...	13·231 lbs.
Revolutions of fan per minute ...	260

The higher evaporative efficiency of the boiler with oil fuel will be particularly noted, this of course means very much increased boiler economy. With higher pressure and larger tubes it is possible to attain a much higher rate of combustion. Throughout the trial no smoke was visible at the chimney, indicating perfect combustion.

In next month's issue we will give a description of the apparatus, together with diagrams illustrating its use on shipboard.

West of Scotland.

THE past month has not witnessed any improvement in the position of the shipbuilding and allied industries on the banks of the Clyde, whilst the abnormally wet weather which has prevailed has greatly impeded the execution of the little work there is in hand.

Matters in the Scottish steel trade are rapidly drifting from bad to worse, and rumours of shutting down are not wanting, whilst those works which are running full time are admittedly only working from hand to mouth, and with no orders ahead to look forward to. The main reason is, of course, the prevailing depression in the shipbuilding industry, which is the largest consumer of steel. Unfortunately, however, the other industries in the district, which, though not bulking so largely as buyers of steel, are yet regarded as steady purchasers—viz., the bridge builders—are suffering from the quiet times, and afford but little relief to the present state of matters.

The termination this month of the steamboat service on the Clyde marks an epoch in the annals of the river, and adds another river to the number which seem unable to support a passenger service. The immediate reason of the discontinuance of the service, which till recently was most popular with the general public, must be looked for in the advent of electric cars on both banks of the river, which, with an almost continuous service and with rapid locomotion, have displaced the river boats with the same relentless force which has already cut deeply into the suburban railway traffic in and around Glasgow. The "Cluthas," as they were called, from the Latin name for the Clyde, had as much sentiment attached to them as the penny steamers of the Thames, or the "Mouches" of the Seine.

The service was commenced about twenty years ago, in accordance with powers conferred on the Clyde Trust by their Act of 1878. The first steamers were built by Messrs. Seath, the well-known firm of Rutherglen; and as the little boats speedily attained considerable popularity, their numbers were augmented until, some twenty years after their inauguration, the Cluthas carried about 3½ million passengers in a single year, earning upwards of £14,000. The fleet has now been dispersed to new owners on the north-east coast, Greenock, and Ireland, and a distinctive feature of Clydeside life has vanished. To no one more than to the casual visitor to Glasgow

will the loss be greater, as the voyage of the Cluthas from above Glasgow bridge as far down as Whiteinch, occupying about three-quarters of an hour at an expenditure of one penny, afforded opportunities of seeing the river, craft in harbour, and shipyards, which will in future only be obtained from the deck of the larger river steamers on their more extended trips. A reduced service was tried during the autumn, but this being also worked at a loss, public opinion endorsed the action of the Clyde Trustees in discontinuing altogether a service which no longer yielded a profit.

The Chilian battleship, *Libertad*, has been carrying on her trials at the "Tail of the Bank," and attained a speed exceeding 19 knots on the measured mile at Skelmorlie. Previously the *Libertad* proceeded to Holyhead at a speed fixed at 17¼ knots, the trials being stopped after 27 hours' steaming, the Chilian Navy Commission being amply satisfied that the results attained could be maintained indefinitely, if desired. The consumption of coal was 1·7 lbs. per hour per i.h.p.

The Clyde Trustees are pushing on the reconstruction of the sheds recently destroyed by fire at Prince's Dock. The work has been entrusted to the firm of Messrs. P. & W. MacLellan, Clutha Works, Glasgow, who have had extended experience of work of this class, and have just completed the large steel jetty for Coatzacoalcos, for the Government of Mexico, through the well-known Westminster firm of Messrs. S. Pearson & Son, Ltd.

During November the Clyde Trustees added another dredger to their already powerful fleet, by the launch of the *Craigiehall* from the yard of Messrs. William Simons & Co., Ltd., Renfrew. The *Craigiehall* is a powerful twin-screw barge-loading dredger, 192 ft. long, 38 ft. in moulded breadth, by 13 ft. moulded depth.

The dredger, which is of the bow-well, bucket-ladder type, is divided into 14 watertight compartments, and is engined by two sets of three-cylinder three-crank compound surface-condensing engines, of 1,000 i.h.p. combined, fitted with steam-reversing gear, both for driving the vessel and for dredging. The boilers are two in number, and of the cylindrical, horizontal type, with working pressure 130 lbs. per sq. in. The arrangements admit of two speeds for the buckets, each of which holds 20 cub. ft. The dredger is manœuvred by steam winches placed fore and aft, each operated by independent two-cylinder engines. Shoots are placed on each side of the dredger for loading into barges, each shoot being worked by its own steam gear. It may be noted, in conclusion, that the new dredger is the sixth of its class owned by the Clyde Trustees, who additionally own 24 hopper barges, a paddle tug, two diving bells, a floating digger barge, 80 punts, in addition to two vehicular ferries with adjustable platforms, two chain ferries, and a number of small cross-river ferries with lowering gangways at each end, and a quantity of miscellaneous plant.

NEW MACHINERY & APPLIANCES

New Feed-Water Regulator.

WE have pleasure in illustrating herewith a new type of feed-water regulator that has been patented by Mr. A. Mumford and Mr. Anthony, of Culver Street, Colchester. Both of the patentees have had a very wide experience of the generation of steam by express boilers, and the new regulator owes its inception to the long-felt need of a reliable apparatus to govern the flow of feed-water under conditions such as are met with in the working of boilers of the above-mentioned type, which are capable of containing only a very little water, and yet are required to rapidly generate large quantities of steam.

By reference to the drawing it will be seen that the float principle has been utilised to form the fundamental feature of the apparatus, the action of which may be explained as follows :—

The delivery of the feed to the boiler is regulated by the boiler check-valve itself. this being of special construction as shown. Water delivered by the feed-pump acts equally to force the check-valve off its seat, and force it on its seat by pressing on the check-piston. At the same time, the boiler pressure is holding the valve down by pressing on top of the check-valve ; therefore the pump has no power to force any feed into the boiler, so long as the water leaking past the check-piston is taken away and not allowed to accumulate in the space underneath.

This leakage water is taken away by a small pipe (shown) to any convenient place where it can be used again. In its passage, it passes through a small regulator valve, worked by a float, this valve opening or shutting by the rise or fall of the water level. When this shuts, water is prevented from escaping from under the check-piston, pressure is accumulated here, and the feed-pump can then lift the check-valve and feed the boiler. When the water rises and opens the regulator-valve, the pressure under the check-piston escapes, and the check-valve closes tightly, shutting off the feed.

The amount of water to be controlled being only what leaks past the check-piston, a regulator of the smallest practicable size can operate the largest feed-check made as easily as the smallest.

When the cock in the leakage pipe is closed, shutting off the regulator, the check-valve becomes an ordinary one, as the check-piston is then inoperative, and hand regulation can be used if desired. The height of the working water level in the boiler can be altered by simply screwing the spindle carrying the regulator valve seat up or down by means of the wheel shown.

The advantages claimed for the apparatus may be summarised thus :—

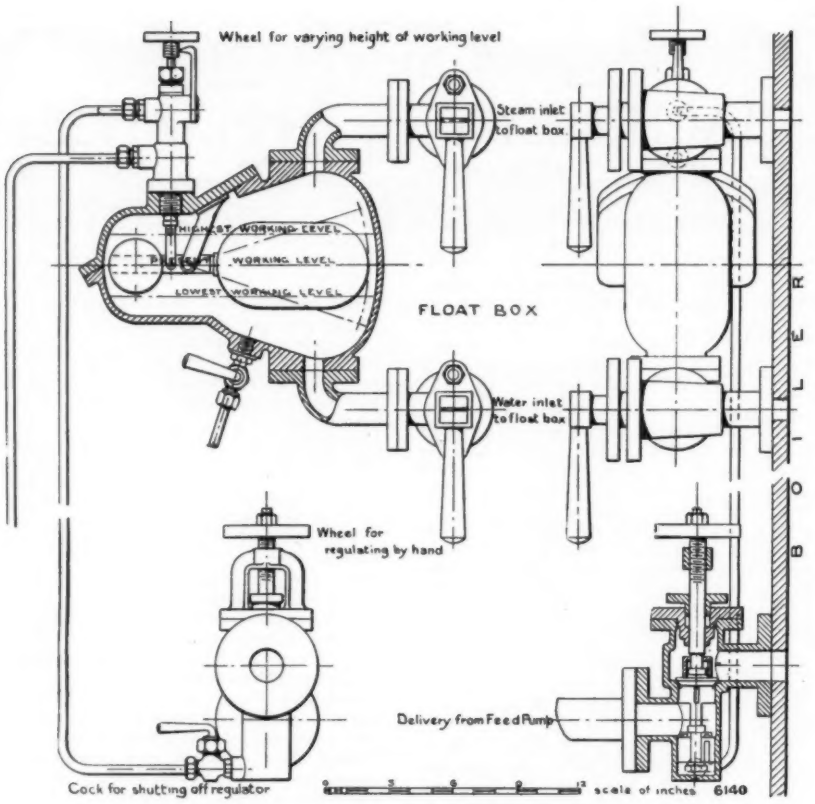
(1) Extreme compactness and lightness, so that the regulator can be fixed as easily as a water gauge : (2) All parts made of gun-metal : (3) Extreme sensitiveness, so that the system is equally applicable to all types of boilers, the variation of level being only half an inch : (4) No working parts in the boiler : (5) When steam and water cocks to float-box are shut, the whole of the working parts can be examined, with the boiler under steam, and this without stopping the feed : (6) When the cover of the float-box is removed, the whole of the working parts are withdrawn : (7) One size regulator can be used for all sized boilers.

—♦—

New Type of Electrically-Driven Air Compressor.

THE accompanying illustration is that of a very compact electrically-driven "Boreas" air compressor, patented and recently introduced by the makers, Messrs. Lacy-Hulbert & Co., Ltd., of 25, Victoria Street, Westminster, S.W.

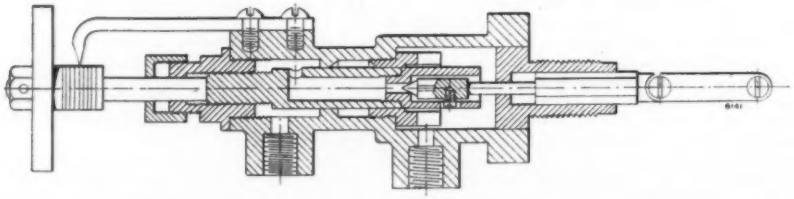
The compressor is fitted with ground steel disc valves, arranged concentrically, that is, the inlet fits into the outlet at the end of the stroke, so that the cylinder clearance is



DETAILS OF MUMFORD AND ANTHONY'S FEED-WATER REGULATOR.

reduced to a minimum. The inlet valves have no springs, while on the delivery side the valves have only one plain spiral spring each. The danger of broken springs is thus much reduced.

The inlet valves are fitted with a gauze strainer, which prevents the entrance of floating particles of grit in the air, and ample provision is made for cooling. The larger sizes are water-cooled.

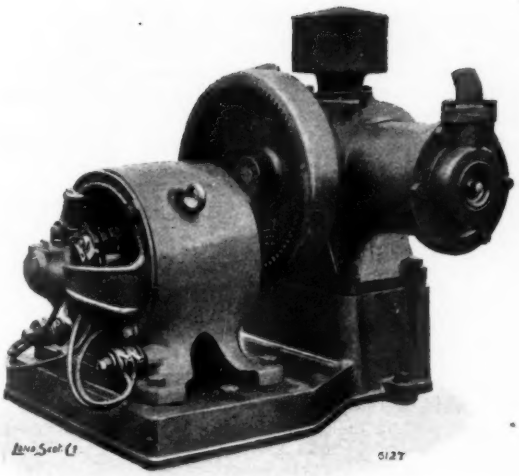


NEW FEED-WATER REGULATOR: SECTION THROUGH REGULATING VALVE CASE.

The moving parts, which are few in number, are carefully balanced, and are rendered dustproof by being entirely enclosed.

The method of using a silencer on air-inlet ensures very silent running. The highest efficiency is claimed for these machines, based upon the exceptionally small clearance due to the special design of the valves.

These compressors are of special interest to central station engineers, as they are particularly adapted for blowing dust out of armatures, etc., for which purpose they are supplied mounted on a bed-plate, which acts as an air receiver and carries the pressure gauge, safety valve, starting rheostat, and electrical equipment complete.



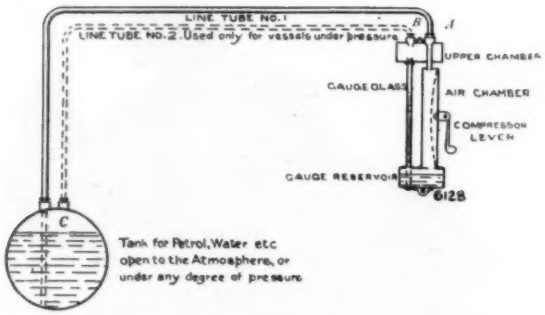
NEW TYPE OF ELECTRICALLY-DRIVEN AIR COMPRESSOR.

Although the machine illustrated is motor-driven, it can be adapted for belt-driving with a heavy flywheel, or direct-driving by a petrol motor. A very efficient vacuum pump is also manufactured by this firm on the lines of the compressor described.

The Depthometer.

AN instrument has recently been designed by Mr. Leonard Murphy, and manufactured by Daniel Miller & Co., Dublin, for indicating the depth of liquids. The latter may be contained in water-tanks, vats, ships' holds, wells, etc., or enclosed in vessels under any degree of pressure, as in the case of petrol tanks in motor cars, and other similar vessels. The instrument may be placed at a distance from, and at any level relative to the tanks, viz. above, below, or on a level with them. Any number of tanks may be connected to one depthometer, and the depth of each ascertained by indicating one at a time. The reading of the indicating column of the depthometer is absolute, marking to a fraction of an inch the depth of the liquid being indicated. The reading can, of course, be reduced proportionately by using mercury or other heavy liquid for the indicating column. No floats or moving parts are used in the vessels being indicated, a fixed pipe of small bore being all that is required. The diagram shows the depthometer attached to a tank containing liquid. The instrument, shown in section, is placed somewhat above the tank, and registers the exact depth of liquid in the tank by means of the column of liquid seen in the gauge glass. When wishing to ascertain the depth of liquid in the vessel connected, it is merely necessary to raise the lever marked "compressor lever," and bring it back again to its starting point. On doing this, the exact depth being measured will be shown by the column in the gauge glass of the depthometer.

The parts of the depthometer shown in the diagram are as follows. Two chambers, fixed one above the other, are connected by a gauge-glass tube, open at both ends, which reaches almost to the bottom of the lower chamber, and only just enters the upper chamber from beneath. The top one is called the "upper chamber," and the lower chamber is called the "gauge reservoir." The latter has attached to its top a flexible "air chamber," capable of being enlarged or reduced in volume by the compressor lever shown in the diagram. To the upper part of the air chamber a short tube and coupling *A* is attached, from which the line tube No. 1 can be carried to the distant vessel, terminating in a dip pipe *C*. If the vessel be under pressure a second line tube, No. 2, is necessary, and is laid beside the first tube, reaching from the top of the tank to upper chamber, coupling at *B* as shown in dotted lines on the diagram. This pipe is, however,



THE DEPTHOMETER.

not used if the vessel be open to the atmosphere, and in that case coupling *B* is left open to the air. The gauge reservoir is next almost filled with the indicating fluid (petrol, water, etc.), and when at rest the liquid should just appear at the base of the visible portion of the gauge glass. The instrument is then ready for use.

The method of working is as follows: Raise the compressor lever to its highest point, thus causing the air chamber to expand and take in a supply of air; the latter enters at coupling *B*, passes through the upper chamber, down the gauge glass, through the liquid in the gauge reservoir, and finally reaches the air chamber. On depressing the lever the air in this chamber becomes compressed, and presses on the liquid in the gauge reservoir. The air cannot, however, return through the gauge glass, as the end of the latter is sealed by the indicating liquid. Some of the air, therefore, passes into the line tube No. 1, and on reaching the tank forces out any liquid which may have risen in the dip pipe *C*, and ultimately the excess of air escapes from the open end of the dip pipe into the liquid in the tank. During this operation the liquid column in the gauge glass of the depthometer will be seen to rise gradually to a certain point and then stand. The column ceases to rise further the moment the air commences to escape at the open end of the dip pipe in the tank, and the column thus shown will be equal in height to the depth of the liquid in the tank, as it will be seen that the air, having completely filled the line tube, has created an exact balance between the column of liquid in the tank and the indicating column of the depthometer.

—•—

New Hydraulic Coal Hoist at Prince's Dock, Glasgow.

THE hoist illustrated herewith is of the suspended pattern, in which everything except the holding-down bolts is kept above the level of the quay, and which only requires as a foundation a solid block of concrete or masonry of sufficient size to take the base of the framing.

The hoist was originally arranged to lift wagons of a gross weight of 20 tons to a height of 50 ft. above the quay, but it was afterwards decided to increase the lifting power to 25 tons, which was effected by the addition of an assistant lifting cylinder attached to the framing. The loaded wagons reach the hoist at quay level, passing over a turntable and weighing machine; and after being lifted to the height required for discharging into the shoot, the empty wagons are lowered to the level of an elevated inclined gantry, by which they are run away to the empty sidings under the influence of gravity. A weighing machine is also provided on the high level adjoining the hoist for re-taring the empty wagons.

The hoist itself consists of a braced steel framing secured to the quay by holding-down bolts. This framing forms the guides for the cradle on which the truck is lifted, and which is fitted with a tipping-frame, by means of which the wagon can be tipped to an angle of 45 degs. at any point in the lift of the hoist, the wagons to be dealt with being all fitted with end doors. The wagon, when tipped, discharges its contents into a shoot on the front of the framing, which is so arranged that it can be adjusted to suit the level of the ship being loaded. The heel end of the shoot is carried by brackets and pawls taken into racks on the front pillars of the framing, safety chains being also provided in case the pawls become disengaged. The point of the shoot is supported by chains leading over pulleys on the top of the hoist framing. When not in use the shoot point is topped up so as not to be in the way of vessels lying alongside. The point of the shoot is fitted with a pair of hinged doors for controlling the flow of the coal, and a removable lengthening piece for fitting on to the end of the shoot is provided. The adjustment of the shoot is effected by making

a temporary attachment of either the heel or point, or both, to the lifting cradle. The lifting and tipping of the cradle is effected by hydraulic cylinders placed vertically on the side of the framing, with the rams working downwards, one of the lifting cylinders being in constant communication with the pressure mains so as to economise power when lowering the empty wagon.

The cradle and tipping-frame are suspended by chains passing over pulleys on the top of the framing to the lifting cylinders already named. On one side of the framing is an auxiliary or anti-breakage crane, having a lifting power of 4¼ tons, by means of which a box can be filled at the point of the shoot, and lowered down into the bottom of the ship and there discharged; this operation being repeated until a cone of coal is formed in the hold of the vessel up to the level of the hatchway, to which the point of the shoot is also adjusted. This in the case of tender coal reduces the breakages in shipment, as, after the cone is once formed, coal can be tipped directly from the wagon without there being any fall from the shoot point. The crane is fitted with hydraulic lifting and turning machinery. The hoist, which was constructed for The Clyde Navigation Co., by Sir W. G. Armstrong, Whitworth & Co., Ltd., has now been at work some little time, and is working most satisfactorily, and recently loaded at the rate of forty-five wagons per hour into a fairly large vessel. All the motions of the hoist and anti-breakage crane are controlled by one man from the elevated cabin on the side of the framing.

COAL HOIST AT GLASGOW HARBOUR.

CORRESPONDENCE.

To the Editor of THE ENGINEERING REVIEW.

SIR :—The thoughtful survey of part of our trade statistics, in the November number must have been interesting and stimulating to all readers, but I beg the favour of space to state briefly some objections to the conclusions. Support was given to Mr. Balfour's plan of duties for retaliative purposes and for negotiation, because "the man with sensible and well-balanced mind . . . adopts every available means for the protection of his life, his health, and his property." That is most true ; but he does not refuse, in deciding on the means to be adopted, to study the weapons in use by others, and the degree of success attending their use of them. Let us then see how retaliation has worked in recent times, where those using it have possessed large and modern forms of the tariff weapon. France and Switzerland had a war of tariffs in 1892-3-4-5. The trade between the countries is shown, averaged, to economise space, in millions of francs, in this table :—

	Swiss Exports to France.	French Exports to Switzerland.
1890 and 1891	(average) 103	(average) 238
1892-3-4-5* ...	,, 75	,, 160
1866-7-8-9 ...	,, 81	,, 197

* Tariff war years.

Russia and Germany fought a tariff war in 1892-3-4. The course of trade is shown below, averaged, in millions of marks :—

	Russian Exports to Germany.	German Exports to Russia.
1890 and 1891	(average) 550	(average) 164
1892-3-4* ...	,, 391	,, 145
1895 and 1896	,, 598	,, 219

* Tariff war years.

Similar effects are to be noted in the long tariff struggle between France and Italy during the years 1888-1898. Averaged below in millions of francs :—

	Italian Exports to France.	French Exports to Italy.
1885-6-7 ...	293	187
1888-1898* ...	134	131
1899	158	191

* Tariff war years.

In each case the results of using tariff retaliation have been (1) a serious loss of business on either side during the war ; (2) a return, after the war, to the fiscal *status quo ante*, with some small concessions on either side ; (3) England gains by her most-favoured-nation clause the benefit of those concessions equally with the combatants. Why should we expect that tariff weapons in our hands will yield better results than France, Germany, Russia, and Italy have been able to obtain from them ?

Turning now to Table I. : Coal, machinery and ships are omitted because "each of them furnishes to foreign rivals the means of competition with our own industries." If we could by refusing to supply these commodities prevent our rivals from acquiring them, the reason might perhaps be a sound one. As they will get the ships and machinery somehow, however, is it not a good thing that we should have the orders ? If so, I contend, Sir, that these large increments of export trade should not be excluded from Tables I. and II. You frequently note, with very proper pride and pleasure, that British firms have secured contracts abroad for locomotives, bridges, machinery, etc., although these certainly add to our rivals' "means of competition with our own industries." Table I. will show much better

results when the full exports are included. The results in Table II. differ widely from those given in Professor Ashley's book, "The Tariff Problem," which was written to support the Tariff Reformers. See page 60 for the following figures of the British exports per head of the population: 1881, £6 13*s.* 11*d.*; 1886, £5 15*s.* 9*d.*; 1891, £6 10*s.* 9*d.*; 1896, £6 1*s.* 2*d.*; 1901, £6 14*s.* 10*d.* Taken in conjunction with the great increases in our sea tonnage and our various invisible exports, these figures cannot be deemed unsatisfactory. The exports per head of Germany, France, and the U.S.A. have also been almost stationary; they are in each case only about half our total per head.

Since 1901 our exports have increased and those of the U.S.A. decreased, as shown in the figures for the first nine months of 1901, 1902, and 1903:—

	United States.	United Kingdom.
1901	£217,983,000	£209,143,000
1902	£192,231,000	£209,501,000
1903	£201,624,000	£217,379,000

Yet the U.S.A. is regarded by protectionists as a state well equipped fiscally, and as likely to crush our home and foreign trade by its competition.

Turning to Table III. (second part): Please compare it with the following figures from Chart III. (Series B), facing page 27 of the "Enquiry" Blue Book:—

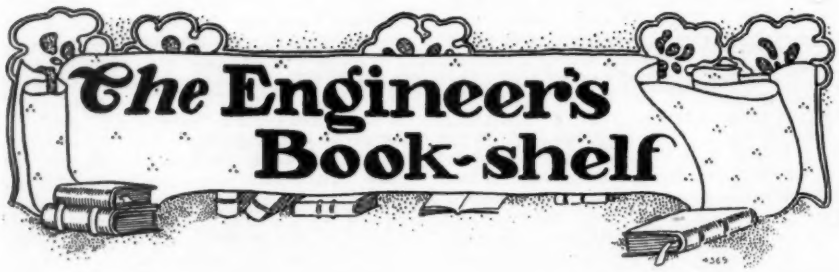
British Exports of Manufactured or Partly Manufactured Goods. (Ships Excluded. Figures stand for Millions of £s).

	Canada and Victoria.	India.	All other Colonies and Possessions.
1890	14	33	40
1902	15¼	32½	60

Here it is to be noted that the high tariff Colonies have not absorbed in 1902 much more of our exports than they took in 1890. The substantial increase has come from the low tariff and free trade (or "tariff for revenue only") parts of the Empire. Colonial trade is undoubtedly worth fostering and seeking, but we shall pay too dearly for it if we are to reverse our whole commercial policy for its sake. The results of the chief experiment in Colonial preference have not been encouraging. Mr. Chamberlain himself said, in his speech to the Premiers (Colonial Conference, 1902): "The net result which I desire to impress upon you is, that in spite of the preference which Canada has given us, their tariff has pressed, and still presses, with the greatest severity upon its best customer, and has favoured the foreigner." Referring to it later, he said: ". . . its results have been altogether disappointing to us, and I think they must have been equally disappointing to its promoters." Finally, Sir, I venture to assert that we can attain the purpose we all have at heart—the increase of British trade—with more certainty and less risk by adopting improved transport facilities, and by throwing off some of the burdens that press on us so heavily in the form of mining royalties, etc., than by rushing into tariff wars. We should go into tariff warfare with lighter weapons and affording a larger target than our opponents. Let us first try legislation to free our canals from the stifling grip of the railways, to modernise them and provide electric haulage; to lift part of the crushing royalties off trade; to compel foreign shipping using our ports to comply with our loadlines; and to further improve our patent laws. These improvements, together with technical education, can do more for us than can complicated and fluctuating customs duties. British trade, prosperous now, could then face the struggles of the future with equanimity.

Yours, etc.,

Nov. 18th, 1903. R. McD.



Traité Théoretique et Pratique des Moteurs à Gaz et à Pétrole. Par Aimé Witz, Ingénieur des Arts et Manufactures, Docteur ès Sciences, Professeur à la Faculté Libre des Sciences de Lille, etc. 4th Edition, refondue et entièrement remaniée. Tom 1, 1903. (Paris: E. Bernard, Imprimeur-Editeur, 29, Quai des Grands-Augustins. Prix des deux volumes. 30 francs.)

The study of gas-engines is becoming a matter of the highest importance for the engineering student. Progress has been rapid in recent years and, although the time has not yet arrived when we may expect to see the steam-engine wholly superseded by the gas-engine, the latter is rapidly advancing in favour, and is destined to become more important each year. The engineer must therefore study the theory of the gas-engine and must be familiar with it in practice; and in view of the growing importance of the petrol-engine, by reason of its application to locomotion on automobiles, he must study this type of engine as carefully and as minutely as he has done in the case of the steam-engine. There are several good English text-books on gas-engines; it would be strange if it were otherwise, as much of the progress and development of that engine is due to British investigators. France, however, can claim as large a share, if not a larger, in this development, and therefore we find that there is an abundance of literature on this subject in the French tongue. The student who wishes to be thorough will not confine himself to the English text-books, but will seek further information from the Continental literature, incidentally profiting thereby in noting other lines of treatment than those with which he is familiar. The present work is distinctly one that may be recommended. The author has an intimate knowledge of the theoretical side of his subject and an intimate knowledge of the practical working of gas and petrol-engines. For the past twenty-five years he has been publishing theoretical discussions, and the present work contains the essence of his past labours, and is based upon them. Originally it appeared as a modest little volume, but in the third edition it swelled out to three volumes, and now in the fourth edition one volume disappears while the size of page in the remaining two is increased. The work is also revised and the text altered to be in accordance with recent developments, so that we have a thoroughly modern work, dealing comprehensively with a very wide subject. Only the first volume of this edition has at present been published. It begins with a very interesting historical sketch of the birth and early life of the gas-engine, tracing its growth and improvement up to the present time. The most striking thing in this chapter is that nearly the whole of this science in its earlier stages is due to Englishmen or Frenchmen. An American occasionally appears, but Germany is practically unrepresented till the appearance of Otto. That inventor certainly achieved much and won fame for his country as well as for himself; but here again a Frenchman must be allowed to share the honour, for his cycle was undoubtedly first disclosed by Beau de Rochas, who showed what must be done in practice, without, however, devising a practical means of doing it. That was left for Otto.

A short chapter on the classification of different types of engine is followed by one on the thermo-dynamics of heat-engines, in which the reader has explained to him so much of the thermal properties of gases and of the heat engine closed cycle as is necessary for an understanding of the operations of gas-engines. This chapter is very clearly written, and the development of the few mathematical equations involved will be followed easily and with interest by the reader. Chapter IV. is devoted to a detailed investigation of the combustible gases used

in engines, and contains a vast amount of information both theoretical and practical. Coal gas—ordinary town gas—is first considered, then water gas, "producer" gas, furnace gases, carburetted air, acetylene, petrol and alcohol are discussed in turn. Special attention may perhaps be directed to the sections dealing with alcohol gas, as little has been done in this country with this fuel in engines. No doubt the restrictions on the manufacture of alcohol are largely responsible for this. The descriptions given of the different systems of manufacturing "poor" or "producer" gases will be found of interest. Chapter V. discusses the generic theory of the gas-engine, comparing the theoretical efficiency of the different types, studying the different cycles, including the "Diesel cycle," and closing with a discussion of entropy diagrams. In view of a recent controversy it is interesting to note that the author, in spite of those who argue against the entropy diagram on account of its unreality, stoutly upholds its value as an aid to the study of the engine. We do not suppose that this would be denied; what English critics have been saying is rather that there is an evil if the student is led to believe that the entropy diagram—relating to a reversible cycle—discloses the actual state of affairs in what is essentially an irreversible cycle. Even these critics, as well as M. Witz, might agree with M. Brunhes that the entropy diagram "permet de voir d'une façon plus intuitive et plus simple, bien choses qui se trouvent vraies." Perhaps we should add that, although directed against some critics, the remarks of M. Witz have obviously no direct reference to the recent controversy to which we have referred.

The two remaining chapters must, in spite of their importance, be dismissed with brief notice. Chapter VI. is highly important and exceedingly instructive. It aims at arriving at an experimental theory of gas-engines by first pointing out the differences between the imaginary theoretical cycles and the real cycles performed by the gas in the engines in industrial use, and then by seeking to separate and investigate those actions, external or internal, of which the general theory has not been able to take account. In this way the action of the wall of the cylinder is discussed at length and its importance explained. Finally, the experimental theory arrived at is considered in the light of facts. The final chapter goes very fully into the question of engine-tests, describing apparatus and methods used, and giving results actually obtained in a large number of specified cases. A few pages at the end are devoted to the determination and calculation of the dimensions of an engine to give a specified power.

The work as a whole is of great merit, and reflects great credit upon the author, who has combined intimate knowledge of his subject with a clear and attractive style of writing. It will no doubt be popular in France, and we recommend it to English readers.

W. C. H.

Papers on Mechanical and Physical Subjects. — By Osborne Reynolds. Vol. III., xvii. and 254 pages. (Cambridge University Press, 1903.) Price 10*s.* 6*d.* net.

The interesting series of engineering and physical papers contained in the first two volumes have already been noticed as they appeared. The present volume is devoted entirely to an elaborate memoir "On the Sub-mechanics of the Universe," which was communicated to the Royal Society at the beginning of last year. Some of the author's earlier investigations suggested to his mind the possibility that the medium of space might be of a granular nature, the grains being in relative motion, and at the same time being subject to varying mean motion. In the present memoir the subject is attacked by a development from first principles, and the question of the general equations of a conservative system. It would be out of place in these columns to discuss the mathematical methods employed in the investigation. The conclusion at which the author arrives is that there is one, and only one, conceivable purely mechanical system capable of accounting for all the physical evidence, as we know it, in the universe; and that it consists of an arrangement, of indefinite extent, of uniform spherical grains, generally in normal piling, and so close that the grains cannot change their neighbours, although continually in relative motion with each other, the grains being of changeless shape and size, thus constituting, to a first approximation, an elastic medium with six axes of elasticity symmetrically placed. The author shows that this solution gives a satisfactory explanation of gravitation, of electrical phenomena, of the propagation of light by transverse waves, of the aberration of light, and of many other physical phenomena. This agreement of his theory with a wide range of observed phenomena makes it worthy of the most careful consideration, in spite of the fact that his mathematical demonstration cannot be considered satisfactory, dependent as it is on the extension of the Maxwell-Boltzmann law of distribution of energy in gases to his system of grains. Burbury has shown that the validity of this

law is, to say the least, extremely questionable even in the case of highly compressed gases, and his arguments would apply with still greater cogency against its validity in the case of the author's system of juxtaposed grains. G. W. DE T.

The Science of Mechanics: E. Mach. Translated from the German by T. McCormack. (The Open Court Publishing Co., Chicago.) Pp. xix and 605. Price 9*s.* 6*d.* net. 1902.

This is the second English edition of this interesting and valuable treatise, which has already passed through four editions in the original. The object of the work consists essentially in the elucidation and exposition of the fundamental principles which underlie the theory of mechanics. The discussion of the subject is to a great extent historical, and contains much interesting information about workers whose names even are scarcely known to students whose acquaintance with the subject has been derived entirely from the ordinary text-books. It is a book which should be read and re-read by every teacher of mechanics. It makes very small demands indeed upon the mathematical knowledge of the reader, and, nevertheless, it gives very clear expositions of the physical meaning of some of the most important fundamental principles of dynamics, such, for instance, as "The Principle of Least Action," which have hitherto been regarded as sealed books to the student whose mathematical equipment is confined within modest limits. The average mathematical reader will also derive great benefit from the presentation from the physical point of view of principles which he may have seldom or never considered apart from the formulæ in which they are usually embodied. G. W. DE T.

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BOOKS RECEIVED.

Gas and Oil Engine Management. A practical guide for users and attendants. Being notes on selection, construction, and management. By M. Powis Bale, M.I.Mech.E., A.M.Inst.C.E. London: Crosby Lockwood & Son, 7, Stationers' Hall Court, E.C. 1903.

Hoisting Machinery. An elementary treatise, including the elements of crane construction and descriptions of the various types of cranes in use. By Joseph Horner, A.M.I.Mech.E. London: Crosby Lockwood & Son, 7, Stationers' Hall Court, E.C. 1903. Price 7*s.* 6*d.* net.

Canada in the Twentieth Century. By A. G. Bradley. Westminster: Archibald Constable & Co., Ltd., 2, Whitehall Gardens. 1903. Price 16*s.* net.

The Analytical Chemistry of Uranium. By H. Brearley. London: Longmans, Green & Co., 39, Paternoster Row, E.C. New York and Bombay. 1903. Price 2*s.* net.

Treatise on Thermo-dynamics. By Dr. Max Planck. Translated by Alexander Ogg, M.A., B.Sc., Ph.D. London: Longmans, Green & Co., 39, Paternoster Row, E.C. New York and Bombay. 1903. Price 7*s* 6*d.* net.

Liquid Fuel and its Combustion. By W. H. Booth. Westminster: Archibald Constable & Co., Ltd., 2, Whitehall Gardens. 1903. Price 24*s.* net.

Iron, Steel, and other Alloys. By Henry Marion Howe, Professor of Metallurgy in Columbia University in the City of New York. Boston, Mass.: Sauveur & Whiting. 1903.

Designing Ironwork. Second series, Part 4. General data on rolled steel joists, compound girders, concrete, and fire-resisting materials; followed by calculations and working drawings for a fire-proof floor. By Henry Adams, M.Inst. C.E., M.I.Mech.E. London: 60, Queen Victoria Street, E.C. 1903. Price 2*s.*

The Practical Engineer Pocket-Book for 1904. Price 1*s.* net. Manchester: Technical Publishing Co., Ltd., 287, Deansgate.

The Practical Engineer Electrical Pocket-Book and Diary for 1904. Manchester: The Technical Publishing Co., Ltd., 287, Deansgate. Price 1*s.* net.

Mineral Industries and Allied Sciences. Subject list in the library of the Patent Office. London: the Patent Office, 25, Southampton Buildings, Chancery Lane, W.C. 1903. Price 6*d.*

Proceedings of the Chemical and Metallurgical Society of South Africa, with Appendix. Feb. 1897—Sept. 1899. Vol. II. Johannesburg, Transvaal. Published by the Society. Edinburgh: R. W. Hunter, 19, George IV. Bridge. New York: *The Engineering and Mining Journal*, 261, Broadway. 21*s.* net.

La Télégraphie sans Fils. L'œuvre de Marconi. Translated from the *Scientific American* of New York. By Emile Guarini. Brussels: Ramlot Frères et Sœurs, rue Grétry 25. Price frs. 2.50. 1903.

Ankylostomiasis: Its Cause, Treatment, and Prevention. A reprint of a series of articles from the *Colliery Guardian*, dealing with this disease, which is very common in tropical and sub-tropical climates, but is confined in temperate zones to workers in mines, tunnels, and brickworks.

The Daily Mail Year-Book for 1904. 20,000 facts of the day, biographies, tables, diagrams, and maps. Edited by Percy L. Parker. London: The Amalgamated Press, Ltd. 1*s.* 6*d.*

Manual of Practical Mathematics. By Frank Castle, M.I.Mech.E. London: Macmillan & Co., Ltd. 6*s.* 1903.

Modern Electric Practice. Vol. I. Edited by Magnus Maclean, M.A., D.Sc. London: The Gresham Publishing Co., 34, Southampton Street, Strand. 1904.

ENGINEERING ABSTRACTS

LIST OF PUBLICATIONS REGULARLY REVIEWED.

Amer. Engin. & Rlrd. Jnl.	American Engineer and Railroad Journal	NEW YORK	2/-
Amer. Machst.	American Machinist	NEW YORK	-/8
Amer. Machy.	American Machinery	NEW YORK	1/4
Ann. Ing. Gand	Annales de l'Association des Ingénieurs de Gand	BRUSSELS	3/-
Aut. Jnl.	Automotor Journal	LONDON	-/6
Brit. Archt.	The British Architect	LONDON	-/8
Brit. Claywkr.	The British Clay-worker	LONDON	1/-
Builder	The Builder	LONDON	-/6
Bldrs.' Jnl.	Builders' Journal and Architectural Record	LONDON	-/4
Bldng. News	Building News	LONDON	-/8
Canad. Mfr.	Canadian Manufacturer	TORONTO	1/3
Coll. Gdn.	The Colliery Guardian	LONDON	-/8
Coll. Jnl.	The Colliery Journal and Mining Engineer	LONDON	1/-
Compte Rendu Soc. Ing. Civ.	Compte Rendu des Travaux de la Société des Ingénieurs Civils de France	PARIS	3/6
Der Mechnr.	Der Mechaniker	BERLIN	1/-
Ding. Poly. Jnl.	Dingler's Polytechnic Journal	BERLIN	3 mos. 7/6
Echo des Mines et Métall.	L'Echo des Mines et de la Metallurgie	PARIS	f.45.00 p.a.
Écl. Élec.	ÉclairageÉlectrique	PARIS	1/8
Elec. Eng.	The Electrical Engineer	LONDON	-/6
Elec. Rev.	Electrical Review	LONDON	-/8
Elec. Rev., N.Y.	The Electrical Review, N.Y.	NEW YORK	1/-
Elec. Times	Electrical Times	LONDON	-/6
Elec. Wld.	Electrical World & Engineer	NEW YORK	1/4
Electrician	The Electrician	LONDON	-/8
Électricien	L'Électricien	PARIS	1/4
Electricity	Electricity	LONDON	-/3
Electricity	Electricity	NEW YORK	1/4
Electro-Chemist	Electro-Chemist & Metallurgist	LONDON	3/-
Elec. Techr.	Der Electro-Techniker	VIENNA	1/-
Elektrit.	Elektritschestvo	ST. PETERSBURG	30/- p.a.
Elek. Rund.	Elektrotechnische Rundschau	FRANKFORT	1/4
Elektrotek. Tidsft.	Elektroteknisk Tidsskrift	COPENHAGEN	1/-
Elektrotek. Tidsft.	Elektroteknisk Tidsskrift	CHRISTIANIA	1/4
Elektrotechn. Zeitschr.	Elektrotechnische Zeitschrift	BERLIN	1/4
Elettricista	L'Elettricista	ROME	1/4
Elettricita	L'Elettricita	MILAN	1/-
Energ. Electrica	La Energia Electrica	MADRID	1/4
Engineer	The Engineer	LONDON	-/8
Engineering	Engineering	LONDON	-/8
Eng. and Min. Jnl.	The Engineering & Mining Journal	NEW YORK	1/4
Eng. Gaz.	The Engineer's Gazette	LONDON	-/8
Eng Mag.	The Engineering Magazine	NEW YORK & LONDON	1/4
Eng. News	The Engineering News	NEW YORK	1/4
Eng. Rec.	The Engineering Record	NEW YORK	1/4
Foundry	The Foundry	CLEVELAND, U.S.A.	1/-
Gas Wld.	The Gas World	LONDON	-/8
Gaz	Le Gaz	PARIS	1/4
Gén. Civil	Le Génie Civil	PARIS	2/-
Glückauf	Glückauf	ESSEN A.D. RUHR	1/4
Ice and Cold Storage	Ice & Cold Storage	LONDON	1/-
Ind. Elec.	L'Industrie Électrique	PARIS	2/-
Iron Age	Iron Age		
Iron and Coal Trades' Rev.	Iron and Coal Trades' Review	LONDON	-/8
Iron and Steel Trades' Jnl.	Iron and Steel Trades' Journal	LONDON	-/6
Jnl. Am. Soc. Naval Engr.	Journal American Society of Naval Engineers	WASHINGTON	25/- p.a.
Jnl. Assoc. Eng. Soc.	Journal of the Association of Engineering Societies	PHILADELPHIA, U.S.A.	2/-
Jnl. Chem. & Metall. Socy.	Journal of the Chemical Metallurgical and Mining Society	JOHANNESBURG	2/8
Jnl. Gas Lighting	The Journal of Gas Lighting	LONDON	-/8
Jnl. Franklin Inst.	Journal of the Franklin Institute	PHILADELPHIA, U.S.A.	2/-

Jnl. I. E. E.	Journal of the Institution of Electrical Engineers	London	Varies from 1/6 to 7/6
Jnl. Iron & Steel Inst.	Journal of the Iron and Steel Institute	London	16/- per vol. (two annually)
Jnl. San. Inst.	Journal of the Sanitary Institute	London	...
Jnl. Soc. Arts	Journal of the Society of Arts	London	-/8
Jnl. Western Soc. Eng.	Journal of the Western Society of Engineers	Chicago, U.S.A.	3/-
Knowledge	Knowledge	London	-/9
La Mach.	La Machine	Geneva	5/- 6 mos.
Light Rly. & Tram. Jnl.	Light Railway and Tramway Journal	London	1/6
Machinery	Machinery	New York	2/-
Marine Engr.	Marine Engineer	London	1/6
Marine Engg.	Marine Engineering	New York	2/-
Mech. Wld.	Mechanical World	Manchester	-/4
Métallurgie	La Métallurgie	Paris	20/- p.a.
Mines and Minerals	Mines and Minerals	Scranton, Pa.	2/-
Mit. Verein. Strassenbahn.	Mittheilungen des Vereines für die Förderung des Local- und Strassenbahnvesens	Vienna	...
Mod. Machy.	Modern Machinery	Chicago	1/4
Nat. Ldry. Jnl.	National Laundry Journal	Chicago	1/4
Nature	Nature	London	-/8
Power	Power	New York	2/-
Pract. Eng.	Practical Engineer	...	-/6
Proc. Am. Soc. C.E.	Proceedings of the American Society Civil Engineers	New York	Mbrs. only
Proc. Can. Soc. C.E.	Proceedings of the Canadian Society of Civil Engineers	...	Mbrs. only
Proc. Engs. Soc. W. Pennsya.	Proceedings of the Engineers Society of Western Pennsylvania	Pittsburg	3/-
Proc. Inst. C. E.	Proceedings of the Institution of Civil Engineers	London	Mbrs. only
Proc. I. Mech. E.	Proceedings of the Institution of Mechanical Engineers	London	Price varies; gnrly. 3/- per part
Proc. Roy. Phil. Soc. Glasgow	Proceedings of the Royal Philosophical Society of Glasgow	Glasgow	10/6
Pub. Health Eng.	Public Health Engineer	London	-/6
Pub. Wks.	Public Works	London	1/3
Quarry	The Quarry	London	-/8
Rev. Tech	La Revue Technique	Paris	2/-
Rlrd. Gaz.	The Railroad Gazette	New York	1/4
Rly. Age	The Railway Age	Chicago	1/4
Rly. & Engg. Rev.	The Railway and Engineering Review	Chicago	1/4
Rly. Mastr. Mech.	Railway Master Mechanic	Chicago	1/4
Rev. Chim. Ind.	La Revue de Chimie Industrielle	Paris	1/4
Sch. Mines Quarty.	School of Mines Quarterly	New York	3/-
Sc. Amer.	Scientific American	New York	1/-
Stahl u. Eisen	Stahl und Eisen	Dusseldorf	1/-
Steamship	The Steamship	Leith	1/-
Stev. Inst. Indic.	Stevens' Institute Indicator	Hoboken, N.J.	2/6
Street Rly. Jnl.	Street Railway Journal	New York	2/6
Surveyor	Surveyor	London	-/6
Techy. Quarty.	Technology Quarterly	Boston	5/-
Tek. Tidst.	Teknisk Tidskrift	Stockholm	1/-
Tek. Uged.	Teknisk Ugeblad	Christiania	1/-
Tram. & Rly. Wld.	The Tramway and Railway World	London	1/4
Trans. Am. I. E.E.	Transactions of the American Institute of Electrical Engineers	New York	Price varies
Trans. Am. I. Ming. Engrs.	Transactions of American Institute of Mining Engineers	New York	Price varies
Trans. Am. Soc. Mech. E.	Transactions of the American Society of Mechanical Engineers	New York	Mbrs. only
Trans. Am. Soc. Nav. E.	Transactions of the American Society of Naval Engineers	New York	30/-
Trans. Civ. Mech. E. Soc.	Transactions of the Civil and Mechanical Engineers' Society.	...	Mbrs. only
Trans. Inst. Eng. & Shipbldrs.	Transactions of the Institution of Engineers and Shipbuilders in Scotland	Glasgow	Price varies
Trans. Soc. E.	Transactions of the Society of Engineers	...	Mbrs. only
Westn. Electn.	Western Electrician	Chicago	1/4
Zeitschr. Vereines Oster. Ing. und Arch.	Zeitschrift des Oestereichischen Ingenieur und Architekten-Vereins	Vienna	1/4
Zeitsch. Vers. Deutsch. Ing.	Zeitschrift des Vereins Deutscher Ingenieure	Berlin	2/-
Zeitsch. Elektrotechnik.	Zeitschrift fur Elektrotechnik	Vienna	1/4
Zeitsch. Elektrochemie	Zeitschrift für Elektrochemie	Halle a S., Germany	2/-

The Publishers of THE ENGINEERING REVIEW will be pleased to obtain and forward any of the above-mentioned publications on receipt of a remittance.

MATERIALS and MEASUREMENTS.

Vexatious and Fallacious Cement Tests.

PERHAPS the most frequent cause of vexation and friction between manufacturer and user is the want of uniformity in the methods of carrying out even the best known and most frequently used tests. Take, for instance, the simple test of fineness, which is ascertained by sifting a weighed quantity through a sieve having a certain number of holes per lineal inch, and ascertaining the residue which will not pass. In the first place, there is no recognised standard as to the thickness of the wire of which the gauze of the sieve is composed; and, secondly, there is no agreement as to how long the sifting shall be continued. It is evident that with a given number of holes per lineal inch, the thicker the wire, the smaller the aperture through which the particles of cement have to pass, and, therefore, the greater the percentage of residue. Quite recently a case came under the author's notice in which the residue on a sieve having 80 holes per lineal inch was in dispute. A sieve obtained from one of the recognised testing-sieve makers showed a residue of 3·6 per cent., whereas the sieve of another well-known maker gave a residue as high as 6 per cent. Each sieve was checked and found to have the correct number of holes, the difference being due simply to a difference in the thickness of the wire. Since the specification only allowed 5 per cent., it made all the difference between the acceptance and rejection of the consignment. The most striking example of an absurdly misleading test is that known as the "marmalade pot," or temperature, test, brought forward a few years ago, and since adopted by engineers, who, if they were to give the matter a moment's consideration, would at once perceive the falsity of the inferences deduced. In view of the facts and experiments briefly set forth in this paper, the author considers he is justified in asserting that the determination of the evolution of heat during setting is based on entirely false premises, and is a vexatious and absurdly misleading test, serving no useful purpose whatever, and he urges the desirability of its being immediately discarded.—**D. B. Butler,** *Vice-Pres. Soc. Eng. Rept. Engineer, Vol. XCVI, No. 2494,* pp. 385–386.

The Testing of Building Stone.

REGARDING the shape of test-piece, it has been determined that a prism whose height is one and a half times the width of its base will give far more accurate results than the cube. Probably the most interesting series of building stone tests during last year was carried on by Mr. Humphrey.* Six types of stone were tested, and it was found that, except in one case, the 2-in. cubes uniformly gave higher results per sq. in. than the 8-in. size. This abnormal result may be perhaps explained on the supposition that, in any given mass of stone, the smaller the specimen the more likely it is to be homogeneous and free from cracks and other defects. *Transverse Strength.*—Little attention is usually paid to testing the transverse strength of building stones, but owing to bad masonry work, or more generally to the unequal settlement of foundations, transverse strains frequently occur, and their effect is shown by vertical cracks in the weaker stones of the walls. *Hardness.*—The resistance of stone to mechanical wear is rarely of sufficient importance to justify testing, when the stone is used strictly as a building material. *Expansion.*—It has long been recognised that much of the lack of durability of building stone is due to the effects of changes of temperature, which operate to disintegrate the stone. The tendency of stone to disintegrate under changes of temperature can obviously be tested directly, and uniformity in the method of applying the test may be obtained without difficulty. *Porosity or Absorption.*—These tests are carried out with a view to determining the probable resistance of the stone to the action of frost. Other things being equal, it is obvious that the stone which absorbs the greatest quantity of water per cub. in. in a given time will be the stone that is subject to the greatest injury at low temperature owing to the freezing of the water contained in it. The action of frost is frequently simulated by using in the absorption test, instead of pure water, a saturated solution of some salt, of which expansion, on solidifying, would tend to crack the stone. *Chemical Tests.*—The practical value of a chemical analysis depends upon the type of rock in question. In the case of granite, trap, or other crystalline igneous rock, an analysis is of little service. With sandstones analyses are somewhat more useful in determining the character of the cementing material. The value of a chemical analysis is greater in the case of limestones and slates, particularly the latter. *Microscopic Examination.*—This is perhaps the most valuable single test. The examination of old buildings and of natural exposures of the stone under test are valuable aids to a determination of its durability.—**Edwin C. Eckel,** *The Quarry, Vol. VIII, No. 95,* pp. 665–668.

* *Trans. Am. Soc. C.E., Vol. XLVIII,* pp. 506–507, 563–

Effect of Wind on Roofs.*

IN our calculations concerning the effect of wind on roofs we have hitherto assumed that the effect would be the same as if the weather side was a plane exposed to the wind, and that there was no effect on the lee side. Mr. Irminger has, however, proved by careful experiments that for planes at sharp angles to the horizon, viz., roofs, the suction is predominant, also that the weather side of a roof is only exposed to a small pressure, while the lee side is exposed to a heavy suction. This shows that the resultant of the wind acts upward and tries to lift the roof from its supports. This is in full agreement with our experiences with broken-down roofs, and the practical man has always bolted light roofs down in spite of the usual theory. I have based my researches on Mr. Irminger's table for long planes. In the table *P* equals the total effect (lbs. per sq. ft.) on a vertical plane, and *Pa* the effect on a plane at

* On the basis of J. O. V. Irminger's experiments.

a degs. with the horizon. The first columns explain themselves; the deduction of the two last ones is explained below. Plotting the results of the annexed table for planes shows that the suction is greater than the pressure. It also shows that future data must be empirical; it will hardly be possible to express the natural irregularities by a practical formula. Both Mr. Irminger and myself should be very glad if this might induce engineers to publish their experiences, and to make further experiments. It would be most useful to find out experimentally the effect of openings in houses and roofs, as well as the force we ought to assume per sq. ft. on the large surfaces of our roofs. The 56 lbs. is got at by the proportionately small surfaces of the Tay Bridge,

Wind Pressure on Roofs.

	Long Plane, Mr. Irminger's Experiment.		Deduced from the Preceding.		Ordinary Roofs.	
					Weather side at Eaves.	Lee Side.
a	Pa Total $\frac{}{p}$	Suction	Pa Pressure $\frac{}{p}$	Pa Suction $\frac{}{p}$	Pa Pressure $\frac{}{p}$	Pa Suction $\frac{}{p}$
°		%				
5	0·23	100	0·000	0·23	0·000	0·16
10	0·45	87	0·058	0·39	0·046	0·26
15	0·47	85	0·070	0·40	0·056	0·27
20	0·48	83	0·082	0·40	0·066	0·27
30	0·60	75	0·150	0·45	0·120	0·31
40	0·75	67	0·25	0·50	0·20	0·34
50	0·84	65	0·29	0·55	0·23	0·37
60	0·90	63	0·33	0·57	0·26	0·39
70	0·95	62	0·36	0·59	...	..
80	0·98	59	0·40	0·58	...	...
90	1·00	57	0·43	0·57	...	...

while experiments at the Forth and Tower Bridges show that a square foot of a large surface is not exposed to anything like that of a small surface.—**Theodor Nielsen, M.Danish I.C.E.,** *Engg., Vol. LXXVI, No. 1971*, pp. 508–510.

ENGINEERING PHYSICS.

Radio-Activity.

Quantitative measurements of radio-activity depend upon the property possessed by the emitted rays of ionising the gas through which they pass, making it capable of carrying a current by the transport of negatively and positively charged carriers to the positive and negative electrodes respectively. The current flowing is a measure of the number of ions produced per second; thus radio-activity may be measured electrically. It has recently been shown that the rays from radio-active substances which produce the ions of normal gaseous conduction are themselves "ions," *i.e.*, moving particles carrying an electric charge; but they differ from the other class in that their chief experimental properties are due to their kinetic energy and not to their charge, while those of the ions which they produce in the gas are the result of the electric charge which they carry. It is possible to give an ion of this latter class so much kinetic energy that it resembles in properties the ions given out by radium and uranium. In studying the conductivity of an ionised gas, the most characteristic feature we observe is the existence of a "saturation current;" that is, that while at first the current increases with e.m.f., there soon comes a point at which the current scarcely changes for a very large increase of e.m.f. In this condition the number of ions produced per second is the same as the number destroyed by passage to the electrodes, by recombination, and by diffusion to the walls; and if q_0 be the number of ions produced per second per c.c., n the number of positive or negative ions present in 1 c.c. of gas, i the current passing through the gas, l the distance between electrodes, and e the charge carried by each ion, then this state of affairs is represented by the equation

$$q_0 = \alpha n^2 + \kappa n + \frac{i}{le},$$

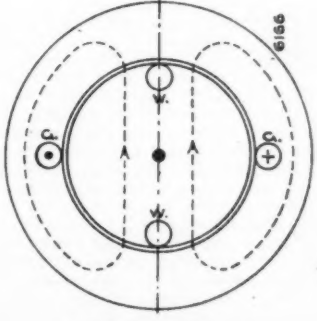
where α depends somewhat on the mutual attraction of the positive and negative ions, and κ is a co-efficient depending on the size and shape of the vessel; or, more generally, when the gas is not in a steady state $\frac{dn}{dt} = q_0 - \alpha n^2 - \kappa n - \frac{i}{le}$.

The author next proceeds to consider the means of determining the value of e, the ionic charge, and makes extensive use of the analysis of this subject given in Professor J. J. Thomson's new work, "Conduction of Electricity through Gases." Using the results of Zeleny's experiments on the velocities of ions, and of Townsend's experiments on their diffusion, it is possible to determine Ne, where N is the number of molecules in 1 c.c of a gas, and is known from the kinetic theory of gases. Thus e is determined, and it is found to be independent of the nature of the gas and of the ionising agent used to produce it, and is equal to the charge carried by the hydrogen atom in electrolysis. From experiments on the clouds formed on expansion of an ionised gas—a property discovered by C. T. R. Wilson—J. J. Thomson has found a value for e, $3{\cdot}4 \times 10^{-10}$ electrostatic units. No direct measurements have yet been made of the masses of the ions produced in gases. It is probable that these ions consist of aggregates of several molecules of the gas, smaller clusters for negative ions than for positive in dry gases, but the reverse in the presence of moisture or vapour, as condensation occurs more readily on the negative ion. But at low pressures the movement of the ion is free—it is not hampered by the condensation of molecules upon it as a nucleus—and it then acquires enormous velocity, and the increase of its kinetic energy above a certain value produces a great change in its properties; it passes from the class of ion, in which the charge is the characteristic, to that in which the energy dominates its properties. In this state the most

characteristic property of the ions is their power to ionise the gas through which they pass—a property particularly studied by Townsend. If the e.m.f. is increased far beyond that required to produce the saturation current in a gas at low pressure, then above a certain point the current again commences to increase until finally the point is reached at which a spark or luminous discharge passes through the gas. This is explained by the formation of fresh ions by collision of original ions with neutral molecules. At first only negative ions are produced, but when the more massive positive ions get up sufficient velocity, then ions of both kinds are freely produced and the action goes on cumulatively. The striated discharge in vacuum tubes may be explained on this theory, and also Hittorf's well-known experiments showing that a discharge refused to pass between electrodes 1 mm. apart in a gas at low pressure, but preferred a circuitous route 375 cms. long. In the space of 1 mm. the ions moving under the electric field cannot acquire the critical velocity required to ionise the gas.—**F. Soddy,** *Electrician, Vol. LII, 1903, Nov. 6,* pp. 81, 82, and *Nov. 13,* pp. 131, 132.—*W. C. H.*

Electrodynamic Condensers.

WHILE designing an apparatus intended for producing oscillating movements in a purely electrical manner for mechanical purposes, the author noticed that his apparatus was capable also of exerting a condenser effect on an electric circuit. The apparatus resembles, as to its external form, an induction motor, being either bi-polar or multi-polar. The exciter coil *G G* is traversed by direct currents. Both the field and armature are, as in the case of induction machines, made of divided iron. The armature coil *W W* is, in its resting position, perpendicular to the plane of the exciter coil; the current is conveyed to the armature either through flexible conductors or sliding rings. As long as only the exciting current is flowing, the armature, as a matter of course, will not be moved. If, however, the armature coil is traversed by an alternating current, vibrating movements will be set up in the armature, inducing e.m.f's. in the exciting field,



ELECTRODYNAMIC CONDENSER.

proportional at any moment to the actual speed of the conductors. In the case of the field strength the number of turns of the armature coil, the length of the armature and the number of periods being given, the amplitude of the conductors oscillating in the field may be so regulated as to give an electromotive force equal to the applied e.m.f. The force, undergoing periodical variations, will be displaced in phase by 90 degs. with regard to the phase of speed. By fitting the shaft of the armature with coils susceptible of being regulated, or by the use of a self-induction circuit, the current strength may be regulated within any limits.—**J. Seidener,** *Zeitsch. Elektrotechnik., Vol. XXI, No. 47, Nov. 23, 1903,* p. 653-656.—*A. G.*

Transmission of Heat in Multiple-effect Evaporators.

THE author's object in this paper is to examine the physical problems raised by the actions in evaporators used in the sugar industry, in order to find the most favourable dimensions for a practical industrial apparatus. The paper is divided into four parts. The first gives an experimental investigation of the form of apparatus under consideration, discussing the circulation in the vertical tubes, the pressures and velocities and the temperature of the solution or juice, and determining the coefficient of transmission in the industrial forms of apparatus. Part II. describes experiments carried out by the author with apparatus of his own construction. Part III. gives a summary of the actual state of our knowledge on the transmission of heat from a vapour to a liquid - (1) from the vapour to the metal walls, (2) by conductivity through the walls, and, (3) from the metal to the liquid. In the fourth and final part of the paper these results are applied to the calculation and construction of industrial apparatus. As an appendix to the paper, the author gives a list of works forming the bibliography of this subject.—**M. Sekutowicz,** *Compte Rendu Soc. Ings. Civ., 1903, No. 9,* pp. 203-256.—*W. C. H.*

Wave-Meters and their Use.

THE underlying principle of the wave-meter described in this paper are as follows:—There are "opened" and "closed" vibrating systems to be distinguished, "opened" systems being those where both the capacity and self-induction are simultaneously present in all the points and more or less uniformly distributed over the whole system. On the other hand, "closed" systems are those where the two above factors are localised separately at given points. A very high damping effect is characteristic of the former kind of systems, whereas "closed" systems, which do not give off any appreciable amount of energy by radiation, are free from any material electric damping. Now wave-meters consist of a standard system, being either "open" or "closed," where either the self-induction or the capacity or both factors are variable, the variations being read on a scale. Resonator coils are open-circuit wave-meters, their use for determining electric wave-lengths being based on the fact that, in the case of resonance the length of the coil will correspond with a quarter of a wave. Though this device be

rather simple in use, the results obtained are far from being as accurate as would correspond with present requirements, owing, in the first place, to the damping effect of the measuring coil and the high sensitiveness of the latter as to capacity differences. The author's wave-meter, on the other hand, comprises a closed vibrating system. The apparatus contains an ammeter, inductively connected to a closed vibrating circuit containing a self-induction and capacity. The instrument is designed so as to allow of the capacity of the closed vibrating circuit being gradually altered within wide limits, when the reading of the ammeter will allow of the resonance being ascertained at a given value of the capacity, and a special device enables the corresponding wave-length to be readily determined. In addition to the capacity, the self-induction may be altered by degrees. In order to use the instrument for determining the wave-length of a given vibrating system, it will have to be coupled to the latter, either electromagnetically or electrostatically or finally galvanically. Of these three coupling methods, the usual electromagnetic coupling is found to allow of the resonance position being ascertained with the highest degree of accuracy. The experiments of the author show the apparatus to be well adapted for use in connection with wireless telegraphy, enabling the wave-length of any electrically vibrating system to be most readily and accurately ascertained and any vibrating phenomena being observed. In addition to practical uses, the wave-meter will be used to advantage in scientific laboratories, replacing complicated old methods.—**J. Dönitz,** *Zeitsch. Elektrotechnik., No. XLV, Nov. 5, 1903,* pp. 920-925.—*A. G.*

CONSTRUCTION.

Concrete Reinforcement.

VERTICAL reinforcement for concrete beams is quite as essential as horizontal reinforcement, and in many cases the horizontal rods are surrounded by **U**-shaped stirrups of band-iron or twisted rods. The writer made a number of tests on beams reinforced with plain and deformed rods on the bottom, and without one exception, all such beams, when tested to destruction under uniform loading, failed by vertical or longitudinal shear. To the writer it seems most natural that rupture should occur in this manner; in fact, he can hardly conceive of its occurring in any other way. It must, of course, be remembered that a beam, when tested both for shear and for bending moment, should be subjected to a uniformly distributed load, and not to a concentrated centre load; for a beam loaded according to this latter method would only develop one-half the shear which exists in a uniformly loaded beam for a given bending moment. European engineers have endeavoured to overcome the difficulty by placing stirrups throughout the beam, their distances apart varying in the inverse ratio of the shear. There seems no doubt that such stirrups accomplish a great deal of good, as they cross the lines of rupture at an angle, and tend to hold the material together. They should be placed, however, in a direction inclined to the horizontal, so as to lie more closely along the line of principal tensile stress; for if they lie in exactly this line, they also cut the actual line of rupture at right angles, and are therefore of maximum efficiency in holding together the concrete where its natural tendency is to open up. Furthermore, if such stirrups are to carry stress, they should carry it into some member capable of receiving it, and the bottom chord member or the horizontal reinforcement is there for that purpose.—**Julius Kahn,** *Assoc. M. Am. Soc. C.E., Eng. Rec., Vol. XLVIII, No. 16,* pp. 465-467.

Impermeable Concrete.

THE investigations by M. Feret, Chief of the Boulogne Laboratory of the Bureau of Bridges and Highways of France, extended over a period of nearly five years, and the final conclusions drawn from them are as follows:—"In all mortars of granulometric composition, the most permeable are those which contain the least quantity of cement. Of all mortars of the same richness, but of varying granulometric composition, those which contain very few fine grains are much more permeable. They are the more so where, with equal proportions of the fine grains, the coarse grains predominate more in relation to the grains of medium size. The minimum permeability is found in mortars where the proportion of medium size grains is small and the coarse and fine grains are about equal to each other." M. Feret's investigation also showed that permeability decreases with age. The passage of water through the mortar frees small particles of the lime or cement and brings them to the surface, where they produce efflorescence. The best method of making cement mortars impermeable, according to the theory of an external coating of lime carried through the mass during percolation, is to add to the concrete at the time of mixing a reasonable proportion of hydrate of lime. Such an addition would form a substance which would close the pores of the concrete.—**Robert W. Lesley,** *Proc. Am. Soc. C.E., Vol. XXIX, No. 6,* pp. 740-755.

Steel Smokestack of the Land Title Building, Philadelphia.

THE smokestack, 74 ins. in diameter and about 370 ft. high, is made with a single shell of plates diminishing from $\frac{7}{16}$ in. at the base to $\frac{3}{16}$ in. at the top. It has a fire-brick lining with an inside diameter of 60 ins., supported at alternate horizontal joints in the shell on 5 × 3-in. angle-iron rings. At every second story the stack is connected at four equidistant points to the floor-beams by means of vertical **Z**-bars riveted to its shell and having slotted holes in the outer flanges which engage bolts through the vertical flanges of horizontal connection angles riveted to the top flanges of the floor beams. The foot of the stack is reinforced by a 6 × $\frac{1}{2}$-in. inside steel ring and a 6 × 4-in. outside flange angle. These are seated on a horizontal annular casting, 98 ins. in diameter outside, 50 ins. inside, and 18 ins. high. This casting has an **I**-shaped cross-section with a top flange 9 ins. wide, and a bottom flange 24 ins. wide, both being stiffened by radial vertical

webs. It rests on the concrete pier, and is filled solid with concrete up to the top of the upper flange.—**Anon.,** *Eng. Rec., Vol. XLVIII, No. 16*, pp. 461-2.

Armoured Concrete Footbridge at Toulouse.

AN armoured concrete foot-bridge over the Midland Canal, having a span of 139 ft., has been recently opened for traffic at Toulouse. The headway over the quay wall is 9 ft. 9 ins., and the height of the road above at the crown 19 ft. At the centre the width is 5 ft., and at the abutments 8 ft. 6 ins. The principle adopted in the design is similar to that employed in the great Luxembourg arch, and consists in constructing the bridge of two parallel arches of armoured concrete, with a space of 2 ft. 6 ins. between them, which is covered by an armoured concrete slab, 10 ins. thick, at the crown of the arch, and 5 ins. at the springings. At the crown the thickness of each of the ribs is 1 ft. 3 ins., increasing to 3 ft. 6 ins. at the springings in the cross-section. At the springings the arches rest upon a mass of concrete, 11 ft. 9 ins. by 11 ft., cut off level with the top of the towing path. The concrete is bedded into the foundations upon an inclined plane measuring 13 ft. 9 ins. by 11 ft. 9 ins., and the foundation block, with an area of 900 sq. ft., consists of plain lime concrete. Steel rods, having a diameter of 1¼ ins., are placed along the extrados, and are prolonged through the whole arch into the foundation. The slab of concrete uniting the ribs is furnished with steel rods of ⅜-in. diam. The weight of the bridge is 290 tons, and the horizontal thrust upon the abutments 200 tons, which, combined with the vertical loading, gives an oblique resultant of 250 tons. The testing of the bridge was effected by depositing along the whole length two layers of sacks, weighing in all 80 lb. per sq. ft., and subsequently adding a load of 200 lb. per running yard. After 12 hrs. half the total weight was removed, and the other half left for another 12 hrs. When the centres were struck the deflection at the crown of the arch amounted to ⅞-in., and the permanent set to ⅛-in. —**Anon.,** *Engineer, Vol. XCVI, No. 2,498*, p. 481.—

New Italian Stone-Arch Bridge.

ILLUSTRATED description of a 230 ft.-span stone-arch bridge at Morbegno, on the Colico-Sondrio Railway. It is the second largest example of the stone-arch type, and has for its characteristic the fact that the footings form a continuation of the arch, constituting a mode of construction much favoured by German engineers.—**Anon.,** *Quarry, Vol. VIII, No. 96.—C. E. A.*

METALLURGY.

Hints on the Inspection of Steels.

THE article deals with the duties of an inspector of steel for engineering purposes in an exhaustive manner, and indicates the points to be observed in testing material for the different purposes, etc. In inspection of Government material there are practically three parties who are interested in construing specifications: the executive department of the Government which requires the steel, the contractor, and the inspector. Something is needed to bring these three parties to a more rational understanding, and it is the object of the article to assist, in part, in this purpose, and it is hoped it will have a tendency to expedite business. The size of ingots used for steel plates varies with the mill in which the plate is rolled, and with requirements of the specifications. Some mills prefer to cast separate ingots for each plate in case of large plates, whereas in others it is the practice to cast large ingots and roll them in the slabbing-mill to a certain width and gauge, and cut them into suitable lengths for the plates required. It is undesirable to have ingots weighing more than eight tons, on account of excessive segregation. The slabs are usually numbered "1" at the first of each year. As each slab is weighed at the shears it is stamped with the consecutive number until the end of the year. In addition to the number stamped on the slab, each one is numbered in accordance with its position on the ingot. Each slab should have stamped upon it the heat and slab number, so that its exact history may be traced. It is important to know from what part of an ingot a plate is rolled, in order to test for uniformity of material due to segregation. As regards tests, if the tensile strength is near the upper limit the inspector should not allow a thinner plate than the test-plate to be rolled without making special tests; and, conversely, a thicker plate should not be rolled without special test. If, however, tensile strength is high and elongation good, thicker plates may be rolled; or if tensile strength is low, thinner plates may be rolled. If a plate is burnt near the edge or end, a special test should be made so as to represent the part nearest the burn. If the plate is suspected of being overheated, a special test should also be made. As a guide for detection of surface defects a descriptive list is given, comprising pipes, cracks, snakes, blisters, laminations, and blow-holes. The importance of a careful surface inspection varies with the use for which the plate is intended. A boiler plate must be practically free from surface defects. Scale, cinder and brick can be easily removed with the hammer, and condition of the metal in the vicinity be readily determined. Thin plates (10 lbs. to 12½ lbs.) should be as free as possible from surface defects. In the manufacture of steel forgings the methods employed in heating, forging and annealing are of the greatest importance. Small forgings are of necessity heated and worked practically uniformly, and the following process of manufacture is not of so much importance; but in regard to large forgings the case is different, and proper heating, working and annealing, to insure best results, are hard to obtain. In the forgings of rounds 6 ins. diameter and over it is best to use a V-shaped die, as this gives a more compact product than a flat die. Generally, the hammering should be worked from end to end of the forging. It is not good practice to rush a forging through the hammer, and then give it another pass to smooth it down. No work should be done on steel when at a blue heat (about 600 degs. Cent.), as it is then very brittle. The heating of metal to be forged is often carelessly

done, even in the best shops, owing to the uneven distribution of heat. The higher the percentage of carbon, the more likely is it to be injured in this way. All forging work requiring more than one heating, or in which metal is only partially heated, should be entirely annealed. In order to anneal properly, the furnace should be so designed that the flame cannot come into contact with the metal or allow an uneven distribution of heat. Specifications for steel castings should be well studied and briefed. The sample used for checking should always be identical with that used by the contractor. High carbon steel produces sound castings, though they are frequently brittle. The limits set by the specifications for the elements of phosphorus and sulphur should, in the main, be the guiding points of the inspector. The purpose of annealing is to make the casting of uniform strength. The castings are brought to the required temperature of 660 degs. to 890 degs. Cent., and "soaked" 12 hours or longer, according to their character, and then gradually cooled, the latter part of the process requiring as much care as the former, if not more. The general defects to be looked for in steel castings are shrinkage cracks, blow-holes, eccentric core-holes, warping of casting, and cracks due to not removing interior cores soon enough. In addition to the above tests, the Bureau of Steam Engineering, Navy Department, also requires the bending of the metal, both hot and cold. The author proceeds to deal with structural steel in an exhaustive manner, and discusses the various points to be observed in assembling the parts, and concludes by discussing the qualities of various paints and protective coverings.—**Lt.-Comdr. Albert Moritz, U.S.N.,** *Trans. Am. Soc. Nav. Eng., Aug., 1903, No. 3,* pp. 609-636.—*H. B. D.*

A Brief Study of the Ferro Metals and their Electrical Manufacture.

METALLIC oxides may be reduced to their metallic elements by two methods. First, by carbon, in which case the ferro obtained always contains a certain amount of the reducing agent; and, second, by means of aluminium, a method yielding alloys practically free from carbon. The heat of the formation of aluminium oxide causes the aluminium to oxidise at the expense of the oxygen of the compound. The first method, that of reduction by carbon, may be effected in the blast furnace or the electric furnace. Ferro-manganese, ferro-silicon, and even ferro-chrome may be obtained from the blast furnace, but the temperature attained is not high enough for the reduction of the oxides of tungsten, vanadium, molybdenum, or titanium, and these oxides are therefore reduced in the electric furnace. Electric furnaces vary in details of construction, and in the mode of application of the current. Generally they consist of a masonry of graphite encased in an iron shell, and connected at the bottom with one of the bus-bars of the current forming the anode. A central cavity in the graphite forms the crucible, and a pencil of carbon, or a bunch of several pencils of an area determined by the amperage used, forms the cathode. The cathode is counter-balanced, and so supported that it may be moved vertically up and down in the centre of the crucible, and is connected by flexible cables to the other bus-bars of the current. The arc is started between the pencil of carbon, the cathode, and the bottom of the hearth, the anode and the materials gradually charged until the crucible is about half full. Reduction proceeds, and fresh charges are added at intervals according to the current and the composition of the ores. The charges consist of an intimate mixture of the concentrated ores and of carbon in some form, both materials being in the state of coarse powder. When sufficient molten alloy has accumulated, the furnace is tapped at an opening in the hearth and charging is again resumed. With the one exception of ferro-silicon, all ferros made in this manner contain appreciable amounts of carbon. As a reducing agent, aluminium may be used in two conditions; either as a powder, as in the Goldschmidt method, or in the form of a bath—a method introduced by the author. The latter method is conducted in an electric furnace of the type described, the walls of the crucible being formed of magnesia bricks, which have the advantage of being bad conductors of heat and of also imparting no carbon to the charge. Sufficient aluminium, in the form of ingots or scrap, to ensure the complete reduction of the oxides is charged into the crucible. When this is liquified the granulated concentrates are added, and a reaction between the oxygen of the ores and the metallic aluminium at once occurs. The furnace becomes incandescent and the current has to be moderated until the reaction is complete; after which it is again turned on, in order to keep the alloy in a state of fluidity. By this method, employing two men at a furnace and 11 h.p., 760 lbs. of ferro-tungsten have been obtained in 30 minutes. The product contained no aluminium, 76 per cent. tungsten, and from 0·6 to 0·9 per cent. carbon. Ferro-chromes of 70 per cent. chromium and ferro-titaniums containing from 10 to 75 per cent. titanium, with carbon from 0·27 to 0·75 per cent., and aluminium from nothing to traces only, have also been obtained. By charging into the bath of molten aluminium a mixture of two or more oxides containing oxide of iron, a multiple ferro may be obtained, such as chrome-titanium-ferro, tungsten-titanium-ferro, chrome-tungsten-ferro, or the like. The economy of the method lies in the lower cost of aluminium in ingot form than in the powdered state necessary to the Goldschmidt method, and the resultant alloys are also freer from aluminium. The uses of the various ferro alloys are also described, and the author submits a series of results showing the beneficial influence of suitable additions of ferro-titanium to cast-iron and steel.—**Auguste J. Rossi,** *Iron Age, Vol. LXXII, No. 20,* pp. 10-15.—*P. L.*

Manganese Ore as a Desulphurising Agent in the Foundry.

THE greater the amount of limestone used as a flux in the cupola the less the amount of sulphur absorbed by the iron from the coke, as illustrated in the following series of actual results:

Limestone per cent. of coke, 0, 6·6, 13·3, 20·0.

26·6, 33·3; sulphur taken up by the iron (per cent. of total sulphur in coke), 59, 50, 37, 35, 16, 14; amount of slag (per cent. of iron), 2·4, 2·9, 5·65, 6·3, 7·9, 8·0. However, an addition of limestone greater than 20 or 25 per cent. of the weight of the coke gives rise to practical difficulties in the large amount and infusible character of the slag formed. Whilst a large body of slag is favourable to desulphurisation, should the amount exceed 5 per cent. of the weight of iron, it gives rise to trouble in melting. The author, quoting experiments of Wuest from *Stahl und Eisen*, shows the beneficial influence of manganese ore in retarding the absorption of sulphur by iron during melting. The charges employed consisted of 12 cwts. of pig-iron, 80 lbs. of coke, 11 lbs. of manganese ore, and 13 lbs. of limestone. The average analysis of the first thirty-three experiments is as follows: Silicon, 2·18 per cent.; manganese, 0·75 per cent.; and sulphur, 0·06 per cent. Using similar charges, but decreasing the weight of manganese ore to 5½ lbs., a series of ten trials gave castings of the following average composition: Silicon, 1·75 per cent.; manganese, 0·65 per cent.; and sulphur, 0·08 per cent. These results were obtained regularly over a long period, and show that manganese ore is an excellent desulphuriser.—**Joseph Wangler,** *Iron Age, Vol. XXII, No. 21*, pp. 14–15.—*P. L.*

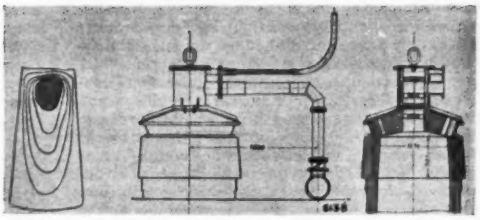


FIG. 1. FIG. 2. FIG. 3.

TOUGHENING STEEL INGOTS.

A New Process for Toughening Steel Ingots in the Molten Condition.

ALL bodies contract by decrease of temperature, and especially strong is this contraction or shrinkage in the passage of metals from the molten to the solid state. After an ingot mould has been filled solidification commences almost immediately, and is represented by the formation of a crust gradually increasing from the exterior to the centre until the whole has solidified As the volume decreases by shrinkage the metal in the mould cannot fill the original space, and there inevitably arises a hollow in the upper portion of the ingot. In Fig. 1 the gradual solidification of a steel ingot is represented by stepwise lines, whilst the obliquely-lined section shows the last remaining hollow, or as it is technically termed, the "pipe." Unless special precautions are taken pipe-free ingots cannot be obtained. One of the most common methods for the elimination of pipe is that of placing a head, which forms a reservoir of liquid metal to supply the shrinkage of the ingot. This feeding head contains the pipe, and on cutting it off a solid ingot results. The method is, however, very costly, the loss of metal in the heads varying from 15 to 30 per cent. and in certain cases reaching 50 per cent. The method of compressing steel whilst fluid obviates pipe, but owing to the cost of the requisite plant is only applicable in special instances. Ingots so compressed are often accompanied by many microscopic flaws, due to the metal retaining a certain amount of gas. The new process of Harmet, of St. Etienne, overcomes this fault by applying the pressure from below, whilst the top of the ingot-mould remains open, thus allowing the gases to escape. This method represents one of the most complete of the compression methods, but it is costly in application. The author's efforts in the direction of producing pipe-free ingots have been based on the principle of the feeder; if this can be kept in a liquid condition for the necessary length of time the formation of a pipe is impossible, for as the solidification gradually proceeds the molten top supplies the demand of the ingot below. The gases are also permitted an escape through this upper molten layer, and it is only in the very highest portion of the ingot that a small pipe can form by the final solidification. The top of the ingot is maintained in the fluid condition by means of a gas-flame, and in order to prevent the formation of a crust this flame is directed down the ingot-mould on to the rising surface of metal, and is continued after the mould is filled for the necessary length of time. The type of burner employed for ingots of from 5 to 20 tons in weight is shown in Figs. 2 and 3, whilst Fig. 4 shows one of the burners in action. In order to attain the requisite temperature the gas, previous to its combustion in the burner, is given a strong foreheating, the air for

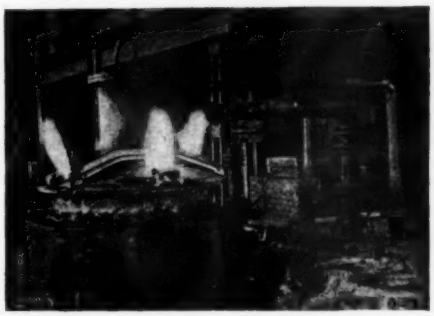


FIG. 4.—TOUGHENED STEEL INGOTS.

combustion being also previously heated. Results obtained from an ingot of 24,235 kgs. show a head loss of only 7 per cent. of the total weight, and one of 14,995 kgs. gave a loss of only 5·3 per cent. The flame was directed on to the latter ingot for a period of 40 mins.; a further example of an ingot weighing 11,550 kgs., on which the flame was directed for 30 mins., showed a head loss of 7·2 per cent. These results show the saving effected in head loss as against the usual methods. The necessary plant for a large steel works would cost from 15,000 to 20,000 mrks, and, according to the capacity of the undertaking, the cost per ton of ingots would vary from 0·5 to 1 mrk., exclusive of the patent duty.—**Julius Riemer,** *Stahl u. Eisen, Vol. XXIII, No. 21,* pp. 1196–1203.—*P. L.*

Electrolytic Copper Refining.

THE author, in a memoir presented to the American Electro-chemical Society, describes a series of experiments conducted by Messrs. Schwab and Baum, in order to determine the most economical conditions of temperature and current. From the results obtained the following conclusions may be drawn. The copper should be refined electrolytically (1) in covered tanks; (2) at a current density of 3·5 amps. q.d.m.; and (3) at a temperature of 70 degs. Cent.—**W. D. Bancroft,** *Mines and Minerals, Vol. XXIV, No. 4,* p. 182 187.—*P. L.*

Light Aluminium Alloys.

THE author, in a paper read before the American Society for Testing Materials, dealt with various alloys of aluminium. These alloys are all hardened and stiffened by working, but during these operations frequent annealing is necessary in order to avoid cracks. Among the chief metals which have been used for alloying with aluminium are found zinc, copper, nickel, magnesium, titanium, tungsten, chromium, manganese and silver. Chromium increases the hardness of aluminium very perceptibly, whilst 2 per cent. of titanium imparts to the metal an elasticity comparable with that of a spring brass, and a tenacity of from 15 to 17·5 tons per sq. in. A triple addition of copper, nickel and manganese yields the hardest light alloy yet produced. Mannesmann, in making aluminium tubes, found that a fraction of 1 per cent. of tungsten made the metal stronger, and increased its resistance to corrosion. An analysis of wolframinium showed it to contain: aluminium, 98·04 per cent.; copper, 0·375 per cent.; tin, 0·105 per cent.; antimony, 1·422 per cent.; and tungsten, only 0·038 per cent. The mechanical properties of this sample were as follows:—

Condition.	Tenacity in lbs. per sq. in.	Extension %.
Hard rolled	52,000	2·14
Annealed	38,000	15·24

Alloys of aluminium and magnesium have been investigated by Dr. Mach. These alloys are commercially known as magnalium, and the mechanical properties of a 2-per-cent. alloy are, in various conditions, as follows:—

Condition.	Tenacity in lbs. per sq. in.	Extension %.
Cast in sand	17,900	3·0
Cast in chills	28,600	2 0
Castings, water-chilled	40,000	1·0
Annealed sheet	25,600	18·0
Hard sheet	41,300	2·7

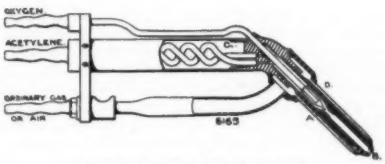
Aluminium alloyed with 10 per cent. magnesium yielded the following mechanical properties:—

Condition.	Tenacity in lbs. per sq. in.	Extension %.
Cast in sand	21,400	2·4
Cast in chills	33,600	3·4
Castings, water-chilled	61,100	4·2

An alloy of 10 per cent. tin with aluminium yields an alloy possessing a whiter colour than that of the pure metal, and, at the same time, one more easily soldered. Zinc alloys readily with aluminium, improving its properties in a manner almost equal to that of the more expensive metals, and owing to the relatively low cost of these alloys they promise to meet with the greater adoption.—**Dr. J. W. Richards,** *Engineering, Vol. LXXVI, No. 1, 977,* p. 705 706.—*P. L.*

The Oxy-acetylene Blow-pipe.

IN this article, devoted to a detailed discussion of the oxy-acetylene blow-pipe, the author thus describes the apparatus illustrated in the figure here reproduced. This represents a blow-pipe on the Fouché system, in which the oxygen from the high-pressure steel flask, where it is usually stored, supplies the necessary velocity of 100 or 150 m. per second. The oxygen enters the apparatus under a pressure of 1 to 1·5 kg., and by means of a sort of minute Giffard's injector *A* it draws in and carries the acetylene at the desired speed to the final outlet *B*. So small is the injector, and so high the speed of the gas, that friction would cause great loss but for the large proportion of oxygen to acetylene and the greater density of the former. Safety is assured by means of a series of long pipes of small diameter, fitted in the handle of the instrument: the acetylene must pass through these pipes before reaching the injector. While preventing the flame from lighting back, they offer only slight assistance to the passage of the gas, and avoid the risk attending the use of explosive gases. Owing to the method of injection, the mixture of the two gases is perfectly homogeneous. This injector system has the further advantage of preventing



THE OXY-ACETYLENE BLOW-PIPE.

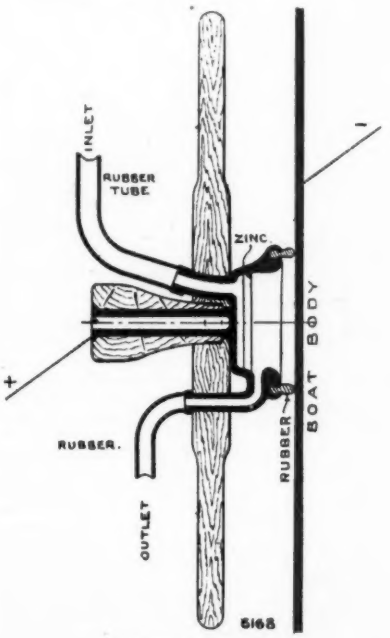
imperfect interior combustions with their resulting deposits of lamp-black, which may quickly clog the tubes. The apparatus is completed by a reciprocating attachment specially useful in dealing with thick plates. A tube *D*, fed by any suitable gas, surrounds the nozzle of the blow-pipe and makes a relatively large flame, which encloses the oxy-acetylene jet while shielding it from the external air. For cooling purpose, air is injected into the tube *D* from a ventilating duct or other convenient source. The flame differs entirely from that of the gases hitherto used in blow-pipes. The central jet—even when quantities as large as 1,000 and 1,500 litres per hour are consumed—is but 3 to 4 mm. in diameter, and from 10 to 15 mm. in length. In the interior of this jet, the gaseous mixture has not yet begun to burn; the disintegration of the acetylene, the liberation of the carbon, and its immediate transformation into carbonic oxide, occur at the surface. The surface of this jet is luminous from the incandescence of the free carbon during its transit from one gaseous combination to the other, and the maximum temperature is found at the tip of the flame.—**Ed. Fcuché,** *Gén. Civil, Vol. XLIII, No. 22*, pp. 340–343.

Galvanic Zinc Deposits on Iron.

ELECTRO-ZINC PLATING, according to the usual processes, takes place too slowly to allow of any stronger deposits being obtained. The author therefore tries to establish improved conditions for similar processes by investigating several electrolytes, out of which a solution, made up of zinc sulphate, sulphuric acid and water, would give the best results, a stout and thick deposit being obtained, with current densities of about 6 amps. per sq. decm., the bath pressure being from 9 to 10 volts. An increase in the current density was made possible by producing a vigorous circulation in the electrolyte. The author next describes a zinc apparatus for plating boat bodies with zinc, where zinc pieces are fixed in a hole and the electrolyte is derived from an upper reservoir.—**O. Gabran,** *Zeitsch. Elektrotechnik., No. 46, Nov. 12, 1903*, pp. 937–939.—*A. G.*

Alumino-Thermics.

IN this paper the inventor of the alumino-thermic welding process gives an account of some recent uses of thermite. The difficulties attendant on the proper composition of the mixture, which consists mainly of an iron oxide-aluminium mixture in about equivalent proportions, are first pointed out. One of the principal requirements is uniformity of the product, physical details having to be particularly investigated and continuously observed in course of manufacture, this necessitating many special machines and devices. In addition to the pure metals and alloys hitherto prepared, the author has recently succeeded in recovering pure fused molybdenum, being a steel-grey metal of a dense structure, containing 1 to 2 per cent. of iron, and being used in manufacturing some special steels. The author, moreover, prepares a high percentage tungsten alloy, being very resistant and easily worked. Metallic-fused silicon (at 98 per cent.) having recently been brought out at reasonable prices, the author thought of replacing part or all of the aluminium by silicon; the result, however, was unfortunately negative. It is next shown that supplying heat from outside to the readily occurring alumino-thermic reaction is quite useless, as is a pre-heating of the re-agent mixture. The province of welding processes by means of thermite, being the most important of alumino-thermic, has lately been considerably enlarged, the existing methods having been further elaborated. The welding of tramway rails has especially been developed, it being shown that the strength of the welded part is about 80 per cent. of the strength of the rail material. Further experiments go to show that only the very short welding part proper, being about 1 to 2 mm. in length, undergoes a slight decrease in strength under the influence of the welding process, whereas the neighbouring rail material does not show any trace of alteration. Thermite has further been used with electric normal railways



GALVANIC ZINC DEPOSITS.

in joining the third rail, in place of the hardly satisfactory copper bonds. Then there are the uses of thermite in repairing broken ship-posts and the weling of forged-iron tubes by means of thermite; the latter process is cheaper than joining by means of flanges, in addition to the weld being readily made even at hardly accessible points. The author gives a table, containing for each calibre of the tubes up to 6 ins. the size of the mould, amount of thermite to be used, etc. A recent application of thermite, viz., for improving iron and steel castings, as developed by the author's assistant, Mr. Mathesius, is finally dealt with. According to this process, the reaction of thermite is produced immediately below the surface of the metal bath, when at a certain point within the bath a high temperature is obtained, the metal given off from the thermite during the combustion is alloyed to the bath at the moment of its production, and finally a violent intermixing of the bath takes place. This results in any gases and slag particles being driven up to the surface, the metal thus becoming denser and of a better quality. The author thinks that new applications of thermite are likely to be found in course of time.—**Dr. Hans Golschmidt,** *Dinglers Polytechnisches Journal, Vol. CCCXVIII, Nos. 47, 48, Nov. 21, 28,* pp. 737-740, 753-760.—*A. G.*

Preventing Pipes and Blow-holes in Ingots and Castings.

To eliminate blow-holes in steel castings or ingots, the writer advises the use of metallic borides in conjunction with titanium alloys. Boron, having a strong affinity for oxygen, forms boron trioxide not only with the free oxygen present, but also with such oxides present as are reducible by boron. This boron trioxide also forms borates with any oxides unreduced by boron. The borates rise to the surface of the metal, there forming a thin layer of slag. The titanium added combines with any nitrogen present to form a stable nitride, thereby eliminating blow-holes and producing solid ingots or castings. The molten metal, being free from oxides, possesses greater fluidity, permitting a more perfect subsidence during cooling, thus giving rise to a smaller pipe.—**Dr. F. C. Weber,** *Iron Age, Vol. LXXII,* pp. 6-7.—*P. L.*

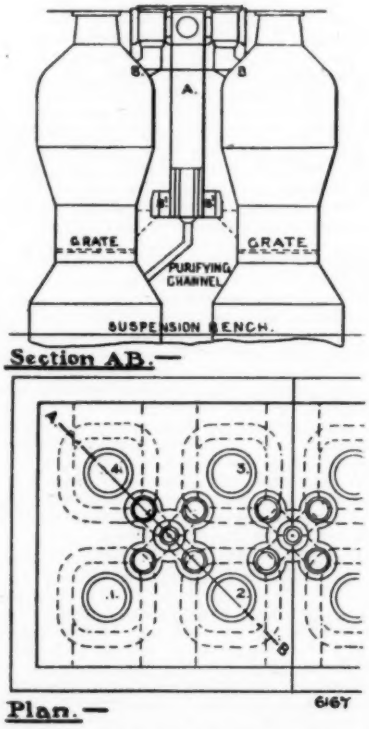
PRIME MOVERS.

Compression in Gas-Engines.

Increased power is obtained from engines having a relatively high compression; as an extreme case in point, a single-cylinder gas-engine 6-in. bore by 10-in. stroke, working on an impulse at each outstroke cycle with no compression, gave only 1 b.h.p., but on being converted to the 4-cycle system with moderate compression gave 3 b.h.p. Another instance is given of two 4-cylinder vertical gasoline engines, one with cylinders 5 ins. by 5-in. stroke and the other with cylinders 6 ins. bore by 8-in. stroke; both being rated at 20 b.h.p. The increased power efficiency of the smaller of these two engines is attributed to the use of higher compression and more effective cooling of the cylinders, combined with more accurately timed actuating valves. A compression limit of 85 lbs. per sq. in. is given for gasoline engines and 100 lbs. compression for engines using natural gas, while with blast-furnace gas a compression of nearly 200 lbs. per sq. in. can be used with advantage. Some causes for loss of compression more commonly met with are leaky pistons and exhaust-valves, wrongly timed inlet and outlet valves with deficient lift or opening, which, singly or together, are responsible for falling-off in power, combined with increased fuel consumption in engines reported to have been entirely satisfactory when first installed.—**A. Stritmatter,** *The Engineer, N. Y., Vol. XL, No. 21.*—*E. B.*

A Process of Converting Fuel into Heating or Power Gases.

Along with the continually increasing use and the ever-growing strain on grate furnaces for heating purposes, the defects inherent in the same have been more and more widely felt. The author thinks the only means of obviating these drawbacks to be a conversion, as perfect as possible, of the fuel into gas, and the use of the latter for heating purposes. In this respect, there



CONVERTING FUEL INTO HEATING GASES.

have not, so far, been any remarkably noticeable advances. As regards, on the other hand, the use of gas for power purposes, there is a keen competition going on between the steam and power engines. Should it be possible to convert, as perfectly as possible, the fuel so far used in generating steam into power gas, the use of gas engines would at once become more economical than that of steam engines in all respects; the more so, if the same process and the same plant could be made to serve both in generating heating and power gas. In the Von der Heydt Royal coal mines near Saarbrücken, Alsatia, tests were carried out for some years resulting in a generating plant being built, in which waste material from the dressing of hard coal is gasified, and the heating and power gas necessary for driving a boiler-plant consisting of eight steam boilers and several gas engines generated. The principle of the process is as follows:—The generators do not require any refilling while the gases are being drawn off, and a number of generators are put in closed connection by suitable means. The various generators are successively charged, ignited, burned out without refilling, disconnected, discharged, recharged and reconnected at given intervals. The tarry gases of the later generators are drawn by means of a common suction device through the generator which has been burning for the longest time, whence they are conveyed off—the air or steam being at the same time drawn off from below. The generator first started up is in full glow nearly throughout when the last is lighted, the upper part of its charge being freed from its tarry products entirely or partly by the heat from the lower burning portion and the neighbouring generators, as well as of the hot gases traversing the same. As the charge is burned through, the generator is either disconnected or, in the case of its being not yet burnt out entirely, connected to the next generator and the gases driven from the latter. The upper part of the charge of a generator started up later, having been exposed to the action of heat in a way similar to the first generator, will equally be free from the tarry products, and thus prepared for the production of gas. As the generators are in a closed connection with one another, the alternative working of the generators goes on continously in a cyclic process. Moreover, as the generators to be discharged are disconnected from the system while the remainder go on working, the removing of slag will not exert any influence on the generation of gas. Experiments so far made have given the following results: (1) The annular generator enables any kind of fuel to be entirely converted into heating or power gases without any distinction of their special properties. (2) Waste matter from the dressing of hard carbon, as so far unused for heating purposes, may advantageously be converted into heating and power gas. (3) The vaporisation of water with waste from the dressing of carbon (percentage in carbon of about 30 per cent.) is treble or quadruple (4) The combustion of carbon in the ring generator for heating purposes is at least not less favourable than combustion on the grate. (5) The cost of heating and power gas generated from ordinary fuel is low, being materially below the present cost of heating and power gas.—**Jahns,** *Glückauf, 39, No 49.* pp. 1183-1184, *Dec. 5th, 1903.—A.G.*

The Use of Superheat in Steam Boilers.

THE trials described by the author were made by M. Dubiau on an old Piguet condensing engine, which used 12 kilos. of steam per h.p. in ordinary work, and 9½ kilos. of steam superheated by the Maiche system. The saving, in spite of a superheating of 134 degs. C. was 20·55 per cent.; but this result is inferior to others obtained, and suggests that the piston and valves of the engine were leaking. The Maiche superheater used in these trials is worked by a separate furnace, therefore it does not interfere with the working of the main boiler, and can easily be put out of circuit for repair or cleaning. It consists of 123 tubes of 3½ mm. diameter, fitted in tubes of 60 mm. diameter, connected at the ends by boxes similar to those of the Belleville boiler. Thus, the surface exposed to the steam is from seven to eight times as great as the exterior surface exposed to the fire, making it more easy to clean off the soot which forms during use. Further, there is no fear of the surface being entirely covered by cinders like the tubes in the flues of the main boiler. The superheater can be regulated at any moment, and works very steadily if a little care is taken. I cannot speak positively as to the exact life of the apparatus; but the maker claims that it is very great, owing to the great thickness of the tubes. The exterior surface of the superheater is only 16 sq. m. for a 125-h.p. engine with a boiler measuring 145 cub. m. M. Maiche claims that superheating limited to 260 degs. C. damages neither the parts of the machine nor the metal of the superheater. If the boilers do not give good results, or if we deduct from the economy the coal used for the independent superheater, the real saving may fall well below 20 per cent. And if every second year a fresh superheater, costing at least 100*f.* per h.p., needs to be provided it will absorb all the saving made on the fuel. It will be some years yet before our steam engines will be able to work with steam at 600 degs. C., and by that time we shall perhaps find it better to do without steam and steam boilers altogether.—**D. Stapfer,** *Bulletin Soc. Scient. Indus. de Marseilles, Vol. XXX, Pts. 3 and 4,* pp. 211-222.

NAVAL ARCHITECTURE.

Experimental Tanks for Testing Ships' Models.

IT is quite evident that experimental tanks form a valuable adjunct to marine engineering work. The importance of such an installation has been recognised by Messrs. Brown & Co., of Clydebank, who have practically completed one in connection with their establishment. The fittings are by Messrs. Kelso & Co., of Glasgow, who have already constructed four sets. Messrs. Denny & Co., of Dumbarton, were the leaders in this line. Since then sets have been made for the Russian Government at St. Petersburg, and for the Italian Government at Spezzia. The canal is 400 ft.

long by 20 ft. broad, and has a depth of 10 ft. It is covered by a shed about 500 ft. by 45 ft. The objections hitherto have been great first cost, but owing to the continually increasing demand for high-speed ships, it is being recognised that only by means of installations of this kind can the demand be successfully met with. It is also commonly reported that a third tank may be built on the Clyde at Greenock.—*The Steamship, Vol. XV, Nov., 1903*, p. 164.—*H. B. D.*

THE author deals with the application of petrol motors as a propelling engine for fishing vessels.

Petrol Motors on Fishing Boats.

The employment of automobiles has given an extraordinary impulse to their manufacture, and it seems at present that there is an important opening for the employment of petrol motors on board fishing vessels. The article deals more particularly with such an installation as has been fitted on board a boat—*The Jean*—belonging to MM. Altazin-Pétyl, of Boulogne, having nearly a total i.h.p. of 300. Many Boulogne boats have already been provided with motors for working the capstan and nets. But it is of great advantage to provide a complete apparatus, so that it may be used as an alternative method of propulsion, should the conditions of weather demand other means than sails. The motors are most economical, both of space and consumption, which are the most important features to be observed. The manual labour of casting and drawing the nets is supplanted by fitting a windlass or capstan of 10 or 12 h.p. Owing to the irregularity of work to be performed, this type of engine is particularly useful. In addition, a great deal of work may be performed, such as hoisting sails, discharging cases of fish, etc. *The Jean* is an auxiliary sailing ship of 209 tons gross measurement and 136 tons net, built last year. She is rigged fore and aft, and has two polemasts, placed far apart, and of nearly the same height. Principal dimensions are: length over all, 118 ft. 1¾ in.; length on water-line, 106 ft. 3 ins.; breadth, 26 ft. 9½ ins.; draught aft, 14 ft. 3 ins. She is provided with two petrol motors—one for propulsion, of 240 h.p., and the other for working the capstan, of 40 h.p. The speed is 8½ knots. In addition to the ordinary fishery work, *The Jean* may be used to carry fish from other boats and transporting it rapidly to port. The propelling apparatus has four cylinders, which are arranged transversely in pairs above the shaft and at an angle of 45 degs. to each other. Each pair of cylinders works on the same crank. The motor develops 240 h.p. when running at 300 revs. per min. The moving masses are balanced and the rotary motion regulated by fly-wheels. The distribution to each cylinder is regulated by three valves—the admission valve for petrol, admission valve for carburetted air, and the escape valve. The petrol is admitted to the interior of the vaporiser pulverised with air, under the action of the suction of the cylinder. The vaporiser, which is the principal part of the machine, is a vertical cylindrical chamber with a double partition, placed on the upper side of the cylinders. The interior chamber is connected with the admission pipe to its lower part; it is shut from the upper part by a piece which carries the petrol valve. The side pipes allow the exterior air to pass in entirely or in part to the vaporiser. The outside annular space is connected with the escape pipe. The burnt gas continually reheats the sides of the vaporiser. The lighting of the gaseous mixture is done by a nickel tube kept incandescent by a lamp, which at the same time heats the bottom of the vaporiser. Owing to these arrangements the vaporisation of the heavy petrol is most effective, the lighting of the mixture is easily performed, and the machine is always quickly started. As soon as the cylinder is working normally the burnt gases reheat the carburetted air of the vaporisers of the next cylinders, and greatly facilitates the regulation of the lamps, for the lighting is afterwards done without difficulty. In addition, the motor is able to develop its total power almost at once. Steadiness of steaming is obtained by means of a powerful regulator, which, when the speed becomes too fast, keeps the escape valve open, and closes the admission lever. The speed of working varies from 100 to 300 revs. per min. After having passed the covering of the vaporiser, the burnt gas reassembles in the first escape chamber; then it is kept back in a second chamber of larger dimensions, so that it may leave through the funnel without pressure or noise. The centrifugal pumps near the motor secure the cooling of the cylinder walls. The lubrication of the cylinders and shaft is done by means of an oil pump. The petrol is stowed in tanks of 20 cub. m. capacity. The motors are put in motion by injecting compressed air into one of the cylinders. This can also be done, if necessary, by means of pulleys and bands from the capstan motor. The screw has two forged steel blades. The capstan motor has two cylinders arranged above the shaft, as in the larger motor. An ordinary engine-room telegraph is also fitted, so that orders may be transmitted directly from the captain to the engineer.—**C. Birault,** *Ingénieur des Arts et Manufactures, Gén. Civil, Vol. XLIII, No. 27*, pp. 423–427.

MARINE ENGINEERING.

THE author gives some notes which are the result of investigation and observation of a sea-going experience. The loss due to friction of plungers, pistons, valves, etc., comprises a large proportion of the loss due to friction. The introduction of high steam pressures and use of superheated steam, which causes rapid vaporisation of the ordinary lubricants, increased piston speed and pressures on wearing surfaces, greatly add to the problem. Suggested remedies to secure the nearest desired conditions are:—(1) Selection of best materials, the friction between which is a minimum; (2) Efficient design; (3) Good and accurate workmanship; (4) Care and treatment to prevent deterioration of the wearing surfaces; (5) Lubricants The materials composing frictional surfaces should be such that the coefficient of friction is at a minimum. Hard cross-grained iron seems to be the most suitable material. In

Internal Lubrication of Marine Machinery.

designing, the following points will materially affect smooth running: Uniform and not excessive pressure of surface of spring valves; fitting relief rings on slide-valves and balance pistons on piston valves; workmanship must be good, and all parts well fitted; sliding surfaces must be kept entirely free from rust; to prevent moisture remaining in the cylinders, etc., the condensers should be allowed to run some time after the engines are stopped; close drains which are open to the atmosphere, indicator cocks, etc., as soon as the engine is shut down. Cylinders of auxiliaries are most likely to suffer from rust due to leaky valves, open drains, or presence of water in the various pockets; if engines are to stand any length of time it is advisable to open them out and wipe them with kerosene, a further coating of vaseline will protect the surfaces from corrosion, besides acting as a good lubricant. Acids contained in impure oil, action of oily depo-it or air collecting in pockets and becoming heated causes pitting of cylinders and internal surfaces; scoring is caused by hard particles left in the cylinders and by the rings nipping the cylinder walls. Slightly rounding off edges of rings might prevent nipping, and providing efficient keepers will prevent ends vibrating and rings nipping. Badly fitted rings involve unequal pressure. The piston rod being out of line will also cause excessive wear on one side of the cylinder and piston rod. When boilers foam, particles of dirt pass into the engines and play havoc with all moving surfaces. Vegetable or animal oils must never be used, on account of the acids causing corrosion in the boilers. Mineral oils have a bad effect on heating surfaces, causing lack of efficiency, burning, etc. Oil, generally, should be used as sparsely as possible. Flake graphite has a high lubricating value, it hardens and improves the wearing surfaces by filling up all minute cavities and irregularities in the surfaces. The same result is obtained with valves and their seats. The piston must be well lubricated in order that it may work with as little friction as possible in its stuffing-box. The introduction of a little graphite to the stuffing-box cylinder oil will greatly improve its lubricating value, and also serve to develop a hard, smooth surface. The best treatment for the delicate secondary valves of steam-pump gear is: (1) Frequent oiling, wiping of all parts with kerosene, and supplying graphite to protect and develop wearing surfaces; (2) Adding a small amount of kerosene occasionally. Kerosene serves to cut out and prevent rust, and has no bad effect on heating surface.—**H. C. Duryea, Lieut. U.S.A.,** *Marine Engg., Vol. VIII, No. 10,* pp. 503-4.—*H.B.D.*

A Problem connected with the Screw Propeller *(contd).*

INVESTIGATION shows that the values of h as a function of s may be closely expressed by a simple linear equation of the form $h = r\,s + q$ (23), hence from (20) $h = r\,s + q = r\left(1 - \frac{Q_1}{T_1}\right) + q$ (24). We can now arrive at an expression for $N(1 - s)$ which shall contain only Q_1, T_1, and r and q. From (17) $N = \sqrt{\frac{T_1}{h}}$, and from (19) $(1 - s) = \frac{Q_1}{T_1}$. Hence $N(1 - s) = \frac{Q_1}{T_1}\sqrt{\frac{T_1}{h}}$ (25), $N(1 - s) = \frac{Q_1}{T_1}\sqrt{\frac{T_1}{r\left(1 - \frac{Q_1}{T_1}\right)} + q}$ (26). Putting x for $N(1 - s)$ and reducing:—$T_1 = \frac{{Q_1}^2}{(r + q)\,{x_1}^2} + \frac{r}{r + q}Q_1$ (27). In this equation, thrust is expressed as a function of torque and speed. By reference to such experimental results as are available and using feet and pounds as units, it may be shown that the value of h can be empirically expressed by $h = \cdot000316\,s + \cdot000006$ (28), whence $r = \cdot000316$ and $q = \cdot000006$. Substituting these values we then have $T_1 = \frac{{Q_1}^2}{\cdot000322\,{x_1}^2} + \frac{\cdot000316}{\cdot000322}Q_1$ (29), or the equivalent $T_1 = 3{,}100\,\frac{Q^2}{{x_1}^2} + \cdot98\,Q_1$ (30). The equation in this form involves T_1, x_1 and Q_1, and is thus explicitly free of dimensions of propeller. For certain purposes, however, it may be of advantage to have the various dimensions and other quantities explicitly

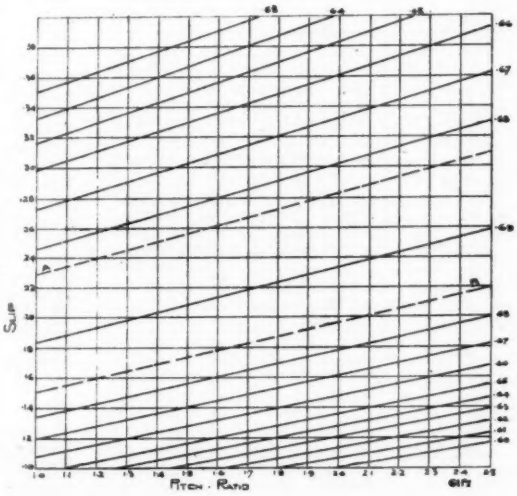


FIG. 1.—SCREW PROPELLER PROBLEM.

involved in the equation—to this end we may substitute in (30) for T_1 and Q_1, their values from (15) and (16), and take for the abscissa $x = p N (1-s)$. Then $x = px_1$ or $x_1 = x \div px$. Making these substitutions in (30), and reducing, we find $T = \frac{122{,}400\, e^2}{d^2 p^2 l\, im}\, Q^2 x^2 + \frac{6{\cdot}16\, e}{p}\, Q$ (31). In practical use it will be found more convenient to use the ton as the unit of force and 10 ft. as the unit for d, p, and $101{\cdot}3\, u$. Making the corresponding changes in the numerical factors we have $T = \frac{274\, e^2}{d^2 p^2 l\, im}\, Q^2 x^2 + \frac{{\cdot}616\, e}{p}\, Q$ (32). For values of efficiency we may be guided by the diagram of Fig. 1, in which, based on Froude's experimental data, the efficiency is expressed as a function of pitch ratio and slip. For value l we have from the same data $l = \frac{p}{d} - {\cdot}17$. There is but a small amount available data at present for values of i and m. For areas of blade about ·36 disc area, and of oval shape, $im = 1$. For suggestions regarding other values for other conditions reference may be made to the author's text-book on "Resistance and Propulsion of Ships," Chapter IV. Suppose, now, we have a given ship with a given turning moment on the shaft, and let the curve $A\,B$ of Fig. 2 represent the corresponding relation between T and x in (32). Next, we plot a curve $C\,D$ between T and x for the ship. This would, in effect, be a curve of resistance plotted on speed, and would therefore, presumably, result most accurately from a series of model experiments. If such are not at hand, the values must be determined from suitable formulæ. It will be noted that only the part of the curve which lies in the vicinity of the curve $A\,B$ is needed. The values of speed and thrust then become known. Then from (15) and (16) $N^2 h$ and $N^2 k$ may be formed, and thence by (19) we find $(1-s)$. From the known values of p and $pN(1-s)$, or speed, we find the remaining unknown N. The result of these operations is to determine, on the assumptions made, the revolutions and speed at which the various conditions will be fulfilled, and the problem is solved. In all diagrams representing equations (30) or (32), it must be remembered that speed involved is that of the propeller through the wake, and that in the expression $x = pN(1-s)$ the slip is "true" slip and not "apparent" slip. In plotting values for the slip-resistance curve, the following routine must be observed. If w denotes the wake speed as a fraction of the speed of advance through the wake, then ratio of speed through the water to the speed through the wake will be $(1+w) : 1$. We then take a series of speeds through the wake and multiply them by $(1+w)$ to find the corresponding speeds through the water. We may then compute resistances at these speeds by the usual formulæ or methods; this will give true or towline resistance. These values must then be multiplied by the ratio of the augmented to the true resistance in order to find the actual thrust-block load. In default of special information, this ratio may be taken as approximately equal to $(1+w)$, the wake factor. The computed values of the resistance multiplied by this factor are then plotted on the speeds through the wake, from which the original start was made. The speed given by the intersection will be the speed through the wake at which the engines, the shaft and propeller are in balance, and this speed multiplied by $(1+w)$ will give the speed through the water as desired. An illustration is given, showing the practical application of the foregoing solutions. The accuracy of the results will depend upon the accuracy with which the formulæ are able to represent the operation of the propeller on the one hand, and the ship resistance on the other. In both directions much is left to be desired. The purpose in the present article is not, however, to discuss propeller or resistance formulæ in themselves.—**W. F. Durand,** *Jnl. Am. Soc. Naval Engr., Vol. XV, No. 3,* pp. 887–897.—*H. B. D.*

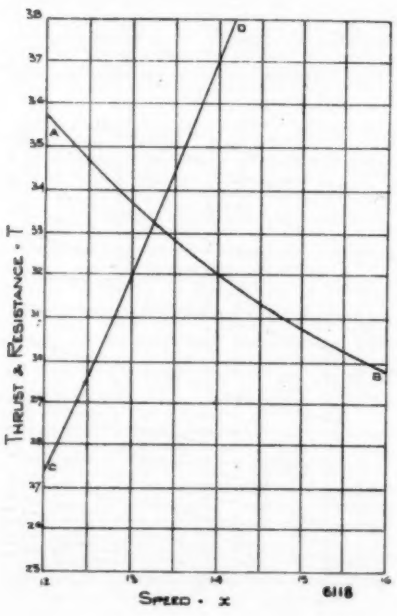
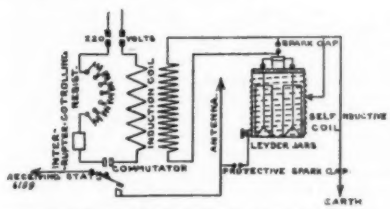


FIG. 2.—SCREW PROPELLER PROBLEM.

APPLIED ELECTRICITY.

The Teplitz-Aussig Wireless Telegraphy Overland Line.

In connection with the Aussig Exhibition for Trade, Industry and Agriculture, the wireless telegraph station communicating with a similar station in the Teplitz Elektrotechnikum, 14km. distant, aroused much interest on account of the conditions of the ground being unfavourable to the transmission of electric waves. In spite of the



THE TEPLITZ-AUSSIG WIRELESS OVERLAND LINE.

numerous hills between the two stations, and of the great level differences of the latter, the apparatus—as constructed by the Berlin Allgemeine Elektricitäts Gesellschaft according to the Slaby-Arco system—worked very accurately and distinctly. The induction coils placed at the transmitting station are worked with continuous current at 250 volts, the interruption of the primary current being effected by means of a mercury turbine interruptor. In order to prevent the sending current from penetrating into the receiving apparatus from the sending wire, being at the same time receiving wire, the primary current is switched in by means of a commutator disconnecting at the same time the sending station. The connection of the sending station is shown in the accompanying diagram. Tuning, as is known, is effected in the Slaby-Arco system by syntonising the lengths of the sending and receiving wires by means of self-induction coils, so as to have a maximum of tension in the antennæ; the latter representing a quarter of a wave length. The antennæ are formed of several longitudinal wires, constituting an inversed triangle, radiating from the inversed point towards the upwards-turned basis of the triangles. The receiving apparatus is tuned as simply as the sending station, though the author indicates another possible method for obtaining the same effect. In the following, some observations made in connection with these experiments are stated: When connecting and disconnecting in the same room a glow lamp, the coherer is found to work: the same is the case when touching the external 220-volt conductor with a piece of metal, whereas in the case of the conductor being touched directly, no signal is obtained; though the contact surface be much higher in the latter case. The current traversing in this case the body is so small as to be not noted at all. Though on very hot days some signals failed to be transmitted, the transmission of despatches was never interrupted. The most important result of these experiments is the fact proved by them, that mountains do not oppose any serious obstacle to wireless telegraph communications.—**M. Albrecht,** *Zeitschr. Elektrotechnik, XXI, No. 40,* pp. 569-570.—*A. G.*

Electrolytic Stripping of Brass from Iron.

In a method of brazing extensively employed in bicycle manufacture, the portions of the frame to be united are dipped bodily into a bath of melted spelter. By this process the outer walls of the tubes receive a thin coating of brass, which has to be removed before they can be enamelled; but all previous attempts to do this electrolytically had failed, because iron being electro-positive to copper in most solutions, the tubes were themselves attacked and corroded more readily than the brazing spelter. To overcome this difficulty the idea was conceived of making iron electro-negative to brass by causing it to assume the passive state; and upon using a solution of sodium nitrate in which this state can be developed it was found that the brass could be completely removed and the iron left intact, provided the current density was not too great and the solution maintained in a proper working condition. Measurements made against a normal electrode of the "calomel" type, whose potential was taken as − 0·56 volt, showed the single potential of iron to be about + 0·2 volt before a current passed, but on closing a circuit through it as anode, a negative value was quickly assumed and could be raised to − 2·0 volts under certain conditions. This is higher than the single potential of platinum and approximate to that of lead peroxide. On the other hand the maximum potential developed by copper is about − 0·65 volt, a value which iron can readily be made to exceed and therefore practically cease to convey any current when the two metals are in circuit in the same solution.—**C. F. Burgess,** *Paper read before Amer. Electro-Chemical Soc., Report Elec. Rev. N. Y., Vol. XIII, No 43,* p. 434.—*E. J. W.*

Investigations on the Pulsations of Continuous Current in Rotary Converters.

These experiments were made with a view of testing the following assertions made some time ago by Professor A. Banti. (1) In the case of a rotary transformer, driven by single-phase alternating current working on ohmic resistance on the continuous-current side, there will be, between the effect as indicated by a wattmeter and the one calculated as a product of current and pressure, a difference as high as 5 per cent. (2) If, on the other hand, the direct-current side be connected to a secondary battery so as to charge the latter, the difference observed will be materially increased, being as high as 15 per cent.; in both cases, the product being greater than the output indicated by the wattmeter. The author's experiments were made on transformers designed by Messrs. Ganz & Co., and the conclusions arrived at are as follows:—In determining the output of the single-phase transformer, there should not be employed any thermic or dynamometric instruments in the direct-current circuit, the figures derived in this way being much too favourable, as the whole of the current measured is not working as energy current with regard to the pressure. The same would be true also of the inverted transformer and double-generator. In the case of a polyphase operation of the transformer, on the other hand, the author was not able to state any pulsation of the direct current; though a recent paper by B. Field (see *The Electrician, No. 24, 1903*) shows this to be possible under certain special conditions.—**E. Cramer,** *Zeitschr. Elektrotechnik., No. 47, Nov. 19, 1903,* pp. 953-959.—*A. G.*

Production of High Frequency Alternating Currents.

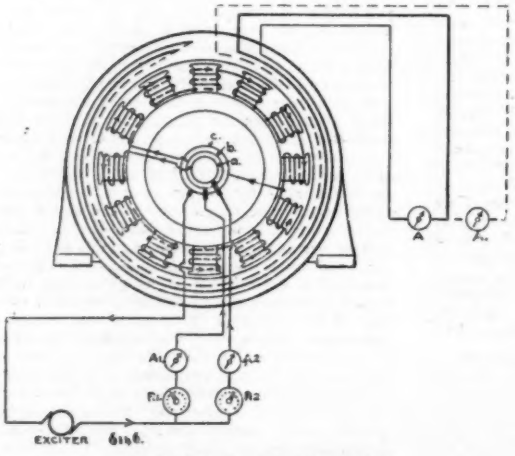
THE author has, in conjunction with Mr. M. Reich, studied a novel principle for generating high-frequency alternating currents. It is shown that the present method of exciting electric vibrations by means of air spark gaps and induction coils gives high-frequency currents of a relatively irregular character. High-tension direct-current sources, such as, for instance, high-tension machines or high-tension accumulators of sufficient current capacity, in connection with vacuum spark gaps, are on the other hand much more suitable for a permanent production of highly efficient electric waves. In order to utilise his principle and to considerably improve the practical conditions of high-frequency currents, high-tension dynamos of 10,000 to 20,000 volts and sufficient resistance should be designed. The method used by the author is based an a principle analogous to the permanent excitation of the air column of an organ pipe, produced by the blowing mechanism, a similar solution being afforded by Duddell's singing arc for the case of slowly vibrating systems. In organ pipes, as well as in any similar periodic mechanical processes, a system susceptible of vibrating is coupled to a stationary stream, so that the intensity of the coupling effect is varied by the vibrations themselves, being greatest in the case of the exciting stationary flux acting in the same direction as the excited flux, whereas in the case of opposite directions a minimum effect is observed. Now electric arcs between metal electrodes seemed to present all the properties of a similar coupling. By means of high-tension continuous currents, using metallic spark gaps placed in the vacuum, the experimenters were able to produce extremely efficient electric vibrations similar to those obtained by means of the Cooper-Hewitt mercury lamp in connection with high-tension alternating currents. A still more suitable method than utilising electric arcs would be afforded by asymmetrical spark gaps formed, for instance, of a point and a plate, though the experiments so far made do not allow of any details being stated. As the working conditions of a given high-frequency system may in each special case be closely adapted to the spark gap, the above process is likely to become useful also for wireless telegraphy purposes.—**Prof. H. Th. Simon,** *Paper read before the 75th Congress of German Naturalists at Cassel, see Physik. Zeitschr., 4, No. 76b,* pp. 737–742.—*A. G.*

Energy Diagram of Electric Circuits.

GENERAL transformers and their diagrams have been largely dealt with of late years. As, however, no diagram both accurate and simple was, so far, forthcoming, the author shows on the three fundamental equations of electric circuits that, not only ordinary transformers, but any desired circuit will possess a circular diagram; this diagram being derived simply and accurately from measurements with circuits at no load, and with short-circuited circuits.—**J. L. Latour,** *Zeitsch. Elektrotechnik, Vol. XXI, No. 44, Nov. 1st, 1903,* pp. 613–617.—*A. G.*

Testing Large Alternators under Full-load Conditions.

THE method suggested by Mordey for testing single alternating-current generators of the synchronous type consisted in dividing the armature coils into two opposed sections of unequal numbers, such that when the machine was run on short circuit with the field fully excited, the larger number of coils acted as generator, and drove the full-load current through the smaller number, which acted as motor. The defect of this arrangement is that the current in the armature weakens the poles on the generator side and strengthens those on the motor side, and gives rise to a magnetic unbalancing of the machine. The same result ensues if, instead of the armature, the field circuit is connected up in two sections, so that the induced e.m.f. are in opposition; and a 3,000-k.w. machine which the author attempted to test in this way threatened to break itself in pieces by reason of the tremendous strains consequent upon its lack of magnetic symmetry. To overcome this difficulty he devised the arrangement shown diagrammatically in the figure as applied to a three-phase machine with a rotating field circuit. This is divided into two equal portions in opposition, but so coupled that they can be traversed by currents of unequal strength Either a third slip-ring must be provided for making contact with the common junction of the two



ALTERNATOR CIRCULATING POWER TEST.

circuits, or else it can be connected to the frame of the machine. By means of the rheostats R and R' in each circuit the exciting current on the generator side is adjusted so much smaller than on the motor side, that the resultant field becomes uniform throughout the machine; and under these conditions it was found that a satisfactory test of the above-mentioned generator could be made with power circulating equivalent to 4,500 kilowatt ampères. Not only can the heating of the armature and field circuits by C^2R losses be accurately determined in this way, but it was experimentally ascertained that the core losses due to hysteresis and eddy currents are also the same in the test as they are when the generator is running under normal conditions.—**B. H. Behrend,** *Elec. Wld., Vol. XLII, No. 18,* pp. 215, 216; *No. 20,* pp. 802, 803.—*E. J. W.*

The Yorkshire Electric Power Co.'s Generating Station.

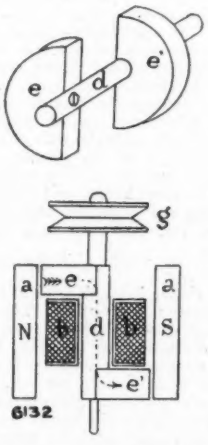
An illustrated description of the Yorkshire Electric Power Co.'s plant, which will shortly be in a position to supply power to consumers. The buildings for the first generating station are in the course of erection, and contracts have been entered into providing for 6,000 kw. of plant and mains. A plan is given of the site location of power-station buildings and arrangements of sidings and roadway. This station is one of the four generating stations which the Power Company propose to erect, and is situated on the banks of the Calder, in the district of Thornhill, on a plot of ground adjoining Ravensthorpe and Thornhill station of the London and North-Western Railway, where a junction is effected with the Lancashire and Yorkshire Railway.—*Electrician, Vol. LII, No. 7.*—*C. E. A.*

Systems of Electricity Distribution.

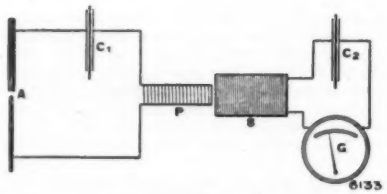
The present trend in the distribution of electricity is to serve large areas from large central stations, and this favours the employment of alternating current, either throughout the system, or transformed to continuous current for final distribution only. As between continuous-current three-wire systems having a pressure up to either 250 or 500 volts across their outers, the advantage does not necessarily always rest with the latter; for it can be shown that in many cases the saving in copper and number of sub-stations is more than offset by the lower efficiency of the higher-voltage lamps, which consume 3·4 to 3·8 watts per c.p. at 250 volts, for about the same useful life as 125-volt lamps that only absorb about 3·1 watts per c.p. There is, moreover, the drawback of arc lamps having to be connected and burnt two in series, or else twin-carbon lamps used, because a single-carbon 250-volt lamp gives an unsteady and objectionably purple arc. The greater the density of the load, the larger the proportion of incandescent-lamp load to total load, the higher the cost of power and of generating apparatus, the more marked the relative advantage of a 250-volt over a 500-volt three-wire system. Large cities, having a central district where the load is of great density, and also suburban districts, may best be served by a combined 250-volt continuous-current three-wire system, and an alternating system, with rotary converters or motor generators to connect the two. The article then proceeds to discuss in some detail various methods of regulating and coupling up in three-wire stations.—**C. T. Mosman,** *Paper read before the Ohio Electric Light Assn., Oct. 1903, Report Elec. Rev. N.Y., Vol. XLIII., No. 18,* pp. 627-9.—*E. J. W.*

Electrical Speed Indicator for Automobiles.

It has often been proposed to employ speed indicators whose action is based on the effect of centrifugal force or of air pressure; but in consequence of their delicacy of structure and of their not being dead beat, the vibration of the vehicle has rendered it impossible for them to yield satisfactory indications. Arrangements hitherto tried for reading the varying e.m.f. of a small dynamo have suffered in much the same way, the constantly changing resistance introduced into the voltmeter circuit at the points of contact of the revolving commutator with the collecting brushes being a great source of unreliability. To overcome these difficulties MM. Chauvin and Arnoux have designed the following apparatus: between the poles of a fixed horse-shoe magnet *a* is placed a bobbin *b* wound with insulated wire. Through the core of the bobbin passes a soft-iron spindle *d*, rotating freely in bearings (not shown in the figure), and having two semicircular armature pieces *e e'*, fixed to it at either end of the bobbin, as shown. It also carries a small pulley *g*, driven from a larger one attached to one of the wheels of the vehicle. When the armatures are in the position illustrated they complete a magnetic circuit that passes longitudinally through the bobbin. A quarter-turn of the spindle, and they form a direct bridge between the



ELECTRICAL SPEED INDICATORS.



FREQUENCY MEASUREMENTS.

magnet poles. Another quarter-turn, and the flux again passes through the bobbin, but in the opposite direction. Another quarter-turn, and the bobbin is again out of the magnetic circuit, and then the armatures once more arrive at the first position. In this way an alternating e.m.f. proportional to the rate of revolution is set up in the bobbin, and is read on a hot-wire voltmeter calibrated in terms of speed.—**J. A. Montpellier,** *Electricien, Vol. XXVI, No. 670,* pp. 273-5.—*E. J. W.*

Frequency Measurements of very Rapidly Alternating Currents.

PEUKERT'S method, as applied to the measurement of the frequency of the "Duddell currents," set up by the singing arc, consists in shunting the carbons with a condenser and self-induction, and then taking simultaneous observations of the ampères in the shunt circuit with a hot-wire ammeter (giving the value T), the volts across the carbons with a Deprez-d'Arsonval dynamometer (giving the value E_1), and also with a hot-wire instrument (giving the value E_2). Then, if N be the frequency and C the capacity of the condenser, $N = \frac{T}{2\pi C \sqrt{E_2^2 - E_1^2}}$. The author's method is diagrammatically illustrated below. The carbons giving the arc A are shunted, as before, with a condenser C and a self-induction P. The latter is the primary of an induction coil, whose secondary circuit S also contains a condenser C_2 in series with a hot-wire ammeter G. The current through the ammeter will attain to a maximum when the natural frequency of the secondary circuit coincides with that of the e.m.f. impressed upon it by the primary circuit. This circumstance enables a very perfect resonance between the two circuits to be readily obtained by adjusting the capacities and self-inductions; and when this has been done the frequency $M = \frac{1}{2\pi\sqrt{L\,C}}$ where C is the capacity of the secondary circuit in farads, and L the co-efficient of self-induction in henries. The latter cannot be determined with sufficient accuracy merely from the dimensions of the coils, but it may be measured electrically to within 0·3 per cent. For frequencies up to 100,000 per sec., Peukert's and the author's methods give similar numerical results; but whereas the former is only correct to within 5 to 10 per cent., the latter is correct to about 1 per cent., and also has the advantage that the frequency of the secondary circuit can be set to any desired value, and the primary adjusted thereto. Above 100,000 per sec. Peukert's method is still less exact, owing to the difficulty of taking really simultaneous readings of the three instruments. The frequency of the alternations may also be measured by photographing the arc by the aid of a revolving mirror, but the results are not believed to be so accurate as those furnished by the method described above.—**J. Wertheim Salomonson,** *Electrician, Vol. XLII, No. 4,* pp. 126-8.—*E. J. W.*

Oil-break Switches and Fuses.

FOR high-potential alternating-current circuits oil-break switches and fuses are rapidly becoming the standard practice. There is good reason to suppose that for every circuit where a break bridged by an arc occurs there is some particular length of arc at which high-potential oscillations will be set up. With the flaring arcs produced on opening an air-break switch these resonance effects may very likely arise and throw an abnormal strain on the insulation of the cables; and this consideration furnishes a weighty argument in favour of oil-breaks, which not only reduce the arcs from feet to inches, but equally shorten their duration, and therefore the amount of heat they generate. There is very little risk of the oil being fired in a well-designed switch, because its arc-quenching properties are so great, but in oil-break fuses the requirements are not so easily met. If the fuse is immersed in the oil the heat normally generated will be liable to raise its temperature to a dangerous extent; while if the fuse link only drops below the surface when ruptured, the arc occurs in a position most favourable for igniting the oil by flashing. For this reason it is advisable to abolish the fuse, and convert the oil-break switch into an automatic cut-out by means of a tripping-gear and coil actuated through a transformer and a relay. The size of the oil-bath is an important consideration in designing switches, and there is a tendency to make it as small as possible, so that, should the oil from any cause be fired, its quantity is not sufficient to be dangerous. It is probable, however, that such a construction in itself augments the risk of ignition, because a large quantity of oil will, by reason of its freer circulation, break the arc more quickly, and absorb the heat generated with much less rise of temperature; besides which, it will be less rapidly fouled by the carbonisation that inevitably accompanies each opening of the switch.—*Elec. Eng., Vol. XXXII, No. 18,* pp. 645-8.—*E. J. W.*

Speed Regulation of Three-phase Motors.

IT is characteristic of polyphase motors arranged for speed regulation by changing the number of poles, that a lower starting torque, output, efficiency, and power factor are obtained with low than with high speed coupling. For this reason, when any considerable starting torque is required, as for cranes or machine tools, the high speed grouping has to be employed, which gives rise to such excessive currents in a short-circuited rotor as may melt out the solder from its connections. To avoid this rush of current, wound rotors with external resis-

tance were introduced, and a wide range of speed regulation is thus provided for; but the efficiency and output falls off at the lower speeds. A third method of speed regulation, introduced in 1901, is obtained by mounting several rotors on the same shaft. Each rotor may be wound for the same load; but for a different number of poles or the higher speed, rotors may be designed for more power than those of lower speed, and the one with the lower speed for a very large starting torque. An overload, for a short time, can be dealt with by coupling all the rotors in parallel. Several examples of such motors, designed by the author, are given with diagrams of the connections necessary for speed changing, and curves showing the performance of each of their rotors. For instance, a three-step, three-h.p. motor had its rotors wound for four, six, and eight poles respectively, and gave the following speeds or light load:—

4-pole rotor alone		...	1,500 revs.
6	,,	,, ...	1,000 ,,
8	,,	,, ...	750 ,,
4 & 6 ,,	in parallel	...	1,060 ,,
6 & 8 ,,	,,	...	790 ,,
4 & 8 ,,	,,	...	770 ,,
4, 6 & 8	,,	...	820 ,,

Other speeds could be obtained by opposing the rotors to one another. The 4- and 6-pole rotors in parallel took a maximum load of 7 h.p. at 930 revolutions. The 6- and 8-pole gave 8·7 h.p. at 690 revolutions; the 4- and 8-pole 6·7 h.p. at 670 revolutions; and the 4-, 6- and 8-pole all together did 10·6 h.p. at 690 revolutions.—**W. Burkard,** *Zeitsch. Elektrotechnik, No. 35, 1903, Report Elec. Eng., Vol. XXXII, No. 20,* pp. 745-9.—*E.J.W.*

The Edison Accumulator for Automobiles.

As regards laboratory tests, this paper covers much the same ground as the report of the author's results which has already appeared.* Further particulars are given of the efficiency of the cell which is considerably lower than that of lead accumulators. The ampère-hour efficiency of the cell tested varied from 50 to 66 per cent. according to the rates of charge and discharge. A rest of 48 hours between charge and discharge reduced the ampère-hour output by 9 per cent., while a rest of 26 days reduced it by 27 per cent. After a rest of 48 hours, discharged and on short circuit, a small cell recovered its normal output or the second discharge after two subsequent recharges. Thirty-eight cells similar to the one tested in the laboratory, were fitted in a motor-car and run about 500 miles by the author, after having previously done about 400 miles in France. They were subjected to discharges and recharges at excessive rates and were, on one occasion, left discharged for ten days, but at the end of the trials their output was exactly the same as at first. The only attention required was the addition of a little distilled water every five or six recharges.—**W. Hibbert,** *Paper read before the I.E.E., Nov. 1903; Report Electrician, Vol. LII, No. 6,* pp. 201-6.—*E.J.W.*

* Feilden's Magazine, Vol. IX., No. 6, p. 529.

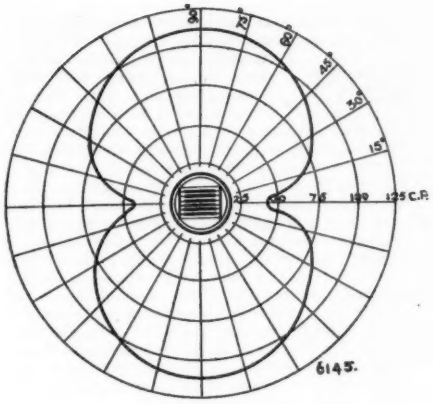


FIG. 1.

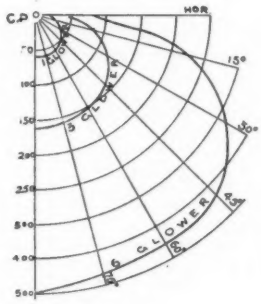


FIG. 2.

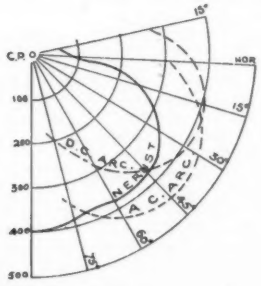


FIG. 3.

PHOTOMETRIC TESTS OF THE NERNST LAMP.

Photometric Tests of the Nernst Lamp.

THESE tests were made upon lamps with one, three, and six glowers respectively, and fitted with various kinds of globes, shades, etc. It was found that the lamps gave their best photometric results with a constant current of 0·4 amps. per glower, and that constancy of voltage was of the utmost importance, as a variation of 1 per cent. made over 14 per cent. difference in the c.p. Fig. 1 shows the distribution of c.p. in a horizontal plane containing the glowers of a six-glower lamp with clear globe. Normal to the glowers, the c.p. is 260 per cent. greater than parallel to them. Fig. 2 shows the vertical distribution of c.p. of one-, three-, and six-glower lamps equipped with clear globes. The curves are a mean of the distribution normal to and parallel to the glowers. The maximum c.p. is directly beneath the lamps, and the light thrown downwards within an angle of 45 degs. from the vertical is very strong. Table I. gives the power consumption per unit of c.p. :—

TABLE I.—RELATIVE POWER CONSUMPTION PER CANDLE-POWER OF NERNST LAMPS WITH VARIOUS GLOBES AND HEATER CASES.

Watts per mean hemispherical candle-power.

No. glowers.	Opal heater case.	Clear heater case.	Clear globe.	Opal globe.	Sand-blasted globes.
1	—	—	2·31	4·19	2·78
3	3·09	2·22	2·33	4·18	2·72
6	2·31	1·90	1·88	3·25	2·29

Watts per mean spherical candle-power.

1	—	—	4·11	4·95	4·30
3	4·55	—	4·04	4·51	4·28
6	—	—	3·30	4·01	3·64

Incidentally the figures show the unreliability of efficiencies expressed in hemispherical c.p., as the results are then so largely dependent upon the nature of the fittings. The increase of efficiency with the number of glowers is probably due to their mutual radiation enabling them to operate at a higher temperature. Fig. 3 gives the curve of mean vertical distribution of light from a six-glower Nernst lamp, equipped with metal shade, in comparison with those of a 6·6-amp. direct-current series arc lamp, and a 7·5-amp. alternating-current series arc lamp, each equipped with an opalescent inner globe, but the former with a clear outer globe, and the latter with a metal shade, these latter being their usual fittings for street service. It will be observed that the Nernst lamp is strong where the arcs are weak, and *vice versâ*. The results are embodied in Table II.

TABLE II.—NERNST AND ARC LAMPS COMPARED.

Candle-power at angle with horizontal.	Nernst 6-glower.	Series arc A. C.	Series arc D. C.
0°	87	310	352
15° below ...	248	375	404
30° ,, ...	335	440	410
45° ,, ...	373	445	375
60° ,, ...	372	420	295
75° ,, ...	380	355	200
Volts	226·0	73·8	71·0
Ampères ...	2·4	7·5	6·6
Watts ...	342·0	469·0	459·0
Mean hemispherical c.p.	289·0	394·0	360·0
Watts per mean hemispherical c.p.	1·87	1·19	1·27

Report of National Electric Light Assocn., Electrician, Vol. LII, No. 4, pp. 128–9.—*E. J. W.*

LIGHTING, HEATING, and VENTILATION.

Heat Radiators using Air instead of Water.

IN the past many have thought that air could be used in radiators, instead of water, for the distribution of heat, and this year the author fitted up a house with this kind of radiator. The house was of two stories, the part served with radiators containing 17,000 cub. ft., divided into ten rooms and two halls. The furnace, which had been in use for thirteen seasons, was set upon the ground floor and burned anthracite coal. The ten radiators installed were supplied from three main pipes; two of these pipes conveyed the air through the attic before it reached any of the seven radiators; they served the ground and first floors; it was an overhead system, as seen in Fig. 3. A fire was lighted at 2 p.m. on Feb. 19. Next morning at 8 o'clock the temperature outdoors was 6 degs. Fahr., and in the house it varied from 44 degs. to 60 degs. The house was never as cold again, and after the first few days the system was better balanced, and the variation within the house seldom exceeded 10 degs. Only once did it reach 16 degs., when the temperature outdoors was about 11 degs., with a gale blowing from the north-west; the temperature within varied from 54 degs. to 70 degs. In passing from the furnace of two of the radiators, the hot air travels a distance of 62 ft. and 71 ft., passing through the attic to do so. In making the circuit from the furnace to these two radiators and back to the furnace, the air travels 107 ft., and makes 13 turns, exclusive of the radiators, which, if counted in, would make the air travel 116 ft. with 21 turns, showing conclusively that turns in the piping have little or no effect upon the flow of

air when it is confined and used in this way, and demonstrating how easily any probable conditions in a medium-sized building can be met with this system. — **George M. Aylsworth,** *Trans. Am. Soc. Heatg. & Ventil. Eng. Rept., The Engineer, N. Y., Vol. XL, No. 17,* pp. 763–764.

Radiation and Illumination.

THIS article gives an outline of the modern aspect of radiation and illumination, describing a great number of researches upon the energy relations between light and heat radiations, the study of which may lead to the perfecting of our illuminants. The writer has made extensive use of a lecture on the "Aims of our Illumination Technics," delivered last year before the Elektrotechnische Verein by Professor Lummar, whose work on this subject appears prominently in this article. As the field covered is very wide, and the investigations described are at once numerous and of diverse character, it is not easy to give the contents of the paper in a short abstract, but it may be said shortly that it gives a *resumé* of the most recent work on the subject, and supplies readers with a large stock of instructive experiments on optics and on heat and light radiation.—**Engineering,** *Vol. LXXVI, No. 1977, Nov. 20, 1903,* pp. 686–690.—*W. C. H.*

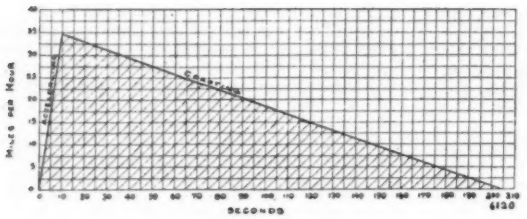
TRACTION.

Four-cylinder Compound Locomotives.

THE author remarks that the system he advocates in the construction of four-cylinder compound locomotives presents marked advantages, in spite of its so-called complication. With the increasing power required for locomotives, it becomes more and more difficult to give sufficient wearing surfaces to the different parts, for the transverse dimensions of the engine remain limited, and thus the length of the wearing surfaces remains limited also. With the system under consideration there is an outside cylinder engine and an inside cylinder engine, each doing about half the total work. For each half of this work there is, therefore, the space usually available in an outside or inside-cylinder engine having to do the whole work. The motion parts can therefore be made very light, and yet with very large wearing surfaces. The two low-pressure cylinders, which are inside the frames, generally drive the crank axle, and as in normal running the low-pressure cylinders do somewhat less than half the total work, the crank axle, in so far as its fatigue comes from the steam-engine proper, is relieved of more than half which it has to bear in an ordinary engine. The division of stresses is carried through to the valve gear, and this has been frequently criticised as a needless complication. If we are willing to sacrifice a good deal of economy in steam to more or less apparent simplification, we can, as has been recently done in America, place the four cylinders one by the side of the other, and distribute the steam by two piston valves, one on each side, thus having only two valve gears. This arrangement entails, in most cases, either connecting all four cylinders to the crank axle, thus giving it all the work to do—which seems a pity—or inconveniently short inside and inconveniently long outside connecting rods. Other arrangements may be adopted. Webb has kept the four valves, one for each cylinder, and drives them by two gears and a rocking lever; but this entails a heavy stress on the valve-gear, and a fixed ratio between the degrees of expansion in the high- and low-pressure cylinders, which gives less adaptability to the varying running conditions. Von Borries has lately tried an arrangement in which the four cylinders, each with separate steam chest and valve, are placed one by the side of the other, all four cylinders driving the crank axle. There are two valve-gears, one on each side, actuating the high- and low-pressure on that side by means of a rocking shaft arrangement giving a varying, but definitely varying, ratio of expansion in these two cylinders. The simplification is more apparent than real, and here again more stress is put upon the crank-axle and the valve-gear than seems advisable with the continually increasing power of modern locomotives. The only objection that can be made to the four valve-gears is the slightly-increased first cost of the engine, and this is most certainly compensated by their reduced wear, increased security against breakdowns, and the adaptability they allow to the varying running conditions. In conclusion, the author states that it has frequently been urged that it is not in the system that the advantages claimed lie, but in the high pressures used. These high pressures most certainly do play a very important part, but it is the system, in a great measure, which has enabled the use of these high pressures without their entailing too much trouble with slide-valves, etc.; and he further states that the first four-cylinder compounds built in 1885 for the Northern of France had only 157 lbs. pressure, and this engine is still as economical in fuel as the later types with pressures of 228 lbs.—**Alfred G. de Glehn,** *The Engineer, Vol. XCVI, No. 2496,* p. 415.—*C. S. L.*

Acceleration—Electric *v.* Steam.

AFTER referring to the increasing importance of the problems involved in satisfactorily dealing with the enormous volume of traffic of a local character in congested areas, the authors remark that it may be generally accepted that a stationary power-house equipped with all modern economising methods must be less expensive in the supply of energy than were the same demands provided by a great number of single-steam units scattered about a given section of a suburban railway. The greater flexibility of the electrically-driven train, the simplification of shunting operations at terminal stations, and the increased speed due to higher acceleration, help to produce a heavy balance in favour of electric traction when viewed from an economical standpoint. It is necessary for the purposes of any comparison between the systems (electricity and steam) to lay down a set of conditions which may be taken to be generally typical of the London suburban roads, and, for the purposes of the argument, we may take it



ACCELERATION—STEAM *v.* ELECTRIC.

that the suburban traffic requires a speed of, say, 22 miles an hour, including stoppages. In order that there may be no question of exaggerating the case in favour of electrically-driven trains, let it be assumed that the stations are one mile apart, that the time of the various stops will range between 10 secs. and 30 secs., and that an average stop of 20 secs. is made. Under these conditions there will be twenty-one intermediate stops, each of 20 secs., making a total of 7 mins., leaving 53 mins. for the 22-mile run, or 144 secs. for the run between two stations, which is equal to a schedule speed of 25 mls. per hour, exclusive of stops. The most usual method of discussing problems of acceleration is by means of diagrams, which are called speed-time curves—that is to say, a curve which shows the relation existing between speed and time from start to finish of a run. At the same time there exists a very useful relation between this curve and the distance covered. As each ordinate of the curve represents a speed value, it will be :—

(1) $y = v\frac{ds}{dt}$, when

v = velocity or speed,
s = distance,
t = time.

The area (da) enclosed by a small portion of the speed-time curve will be

(2) $da = y\,dt$, or according to formula (1).

(3) $da = ds$.

The integration of this formula will give, when substituting $v\,dt$ for ds,

(4) $A = \int_{t^0}^{t^1} v\,dt = s$,

which says the area enclosed by a speed-time curve between any two times is equal to the distance traversed between those times. For example, on the curves given in the paper one square is equal to $\frac{2{\cdot}5 \times 5 \times 5{,}280}{3{,}600}$ ft., and consequently a run over one mile will be represented if the speed-time curve encloses 288 squares. Proceeding to a consideration of the speed-time curves, six of these in all are given, and No. 3 (that illustrated herewith) is typical of the others, and the authors remark in relation to it: "If it were possible to coast a train to a standstill, and not to brake at all, then no energy would be lost, and the total of energy applied during the acceleration period would be equal to the amount of energy necessary under all conditions to make the run in that time. Such a run is shown in the figure, but the conditions which we laid down at the beginning do not allow such an ideal run to be made. Though this curve shows the run starting with an acceleration of 5 ft. per sec., 205 secs. would be required in which to make the one-mile run in such a way. The speed, and consequently the kinetic energy stored to make the run in the specified time is too great to get rid of this kinetic energy simply by coasting. Whilst it is not possible to utilise the total amount of kinetic energy necessary for acceleration, it is evident that enormous differences in the amount of energy to be applied will occur according to the manner in which the run is performed." Some comparative examples dealing with ideal runs made by electrical and steam locomotives under precisely similar conditions are next given, but it must always be borne in mind that, although the authors appear to have used their best endeavours to include only matter which is reasonably logical and fair, still the figures are wholly of a suppositionary character, and appear to more or less favour the electrical equipment, which in every case comes out with the better results.—**P. Walter d'Alton,** *M.Inst C.E., and* **Dr. John Mannheim,** *Engineer, Nov. 6, 1903, Vol. XCVI, No. 2,497,* pp. 443, 444.—*C. S. L.*

Creeping Rails.*

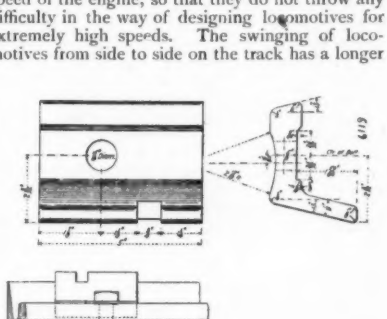
THE subject of creeping rails may properly be divided under three heads, viz. cause, effect and remedy. The principal cause of rails creeping on double-track railways is the fact that the traffic on a given line is all in one direction, and the heavier and faster the trains the more the rails will creep. This is especially true on heavy down grades where all trains maintain high speed. The pilot-wheels of an engine are always running up-hill, regardless of the gradient of the line, and it is this that pushes the rails ahead, or in other words, makes the rails creep. Other and minor causes tend to produce the same effect in a smaller degree. On single-track railways the rails do not creep entirely in one direction, as on double tracks. The effects of creeping are varied. Where there are cross-overs between parallel tracks, the switches and frogs run ahead in the direction of the traffic, necessitating moving tracks back in order to preserve the proper alignment of main track. Where railroads cross at grade, especially at points where there are several parallel tracks in each direction, the effects of creeping are quite serious. At crossings on double tracks, where trains run at high speed, it is absolutely necessary to keep all tracks in proper

* Paper read before the Roadmasters' and Maintenance of Way Convention of the Chicago, Burlington, and Quincy Rly.

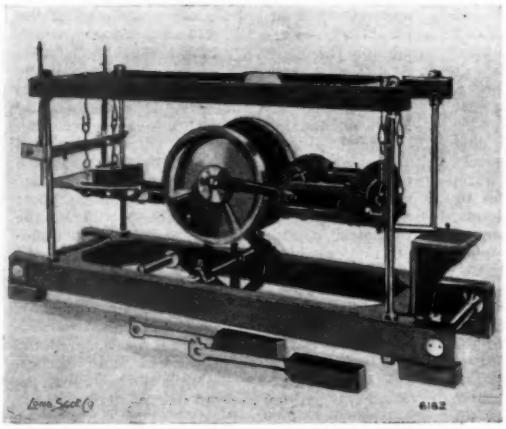
alignment. To do this it is necessary to prevent the rails from creeping, or resort to the constant practice of cutting rails or using short pieces and moving crossings back to their proper positions. Under certain conditions the rails on one side will creep more than on the other, and this has a tendency to move the ties out of place, so that they are not at right angles to the rails. This causes a tightening of the gauge of the track, and produces an irregular line, and these are readily perceptible to the eye. Rails creep more in warm than in cold weather. This is accounted for by expansion of the rails, which forms tight joints, making an almost solid rail for long distances. The best remedy which has been found is to lay the rails broken joints, with heavy angle-bars slotted at each end for spikes; and to place an anchor on the middle of each rail, opposite the joints, where 30-ft. rails are used. This gives an anchorage every 15 ft., and greatly reduces the creeping. The anchors can also be applied to the middle of rails with laid "square joints," by placing anchors directly opposite each other, so they can be spiked to the same tie. For the anchor the author's company use a section of our standard angle-bar, 5 ins. long, with a hole drilled through it, and slots cut out for the spikes. They drill a hole through the rail, and these 5-in. sections of angle-bars are put on the rail the same as a regular angle bar, and are also spiked in the slots to the tie. Their standard angle-bars are 38 ins. long, making a "three-tie joint." The angle-bars are slotted so as to make an anchor on the two outer ties, near the ends of the angle-bars. About opposite one end of the angle-bar, and on the same tie which is anchored by the slot in the angle-bar, we place the 5-in. anchor splice and spike it to the same tie. This device has proved in actual practice during the past ten years to greatly reduce the creeping of rails, and it tends to hold the rails in their proper position. It has been so successful that they use it in all cases on double lines.—**F. J. Allen,** *Rlrd. Gaz., Oct. 16, 1903, Vol. XXXV,* No. 42.—*C. E. A.*

Disturbing Influences of a Locomotive's Reciprocating Parts.

THE model shown in the illustration was made for the Berlin Technical School for the study of disturbances set up in a locomotive by the unbalanced moving parts. It consists of a frame hung from the four corners, and carrying a pair of wheels on an axle, which has four cranks. These cranks can be coupled by connecting-rods to four pistons working in horizontal guides. Two of the cranks are outside and two inside the wheels, so that the model can represent a two-cylinder outside-connected engine, a two-cylinder inside-connected engine or a four-cylinder engine. The linear scale of the model is about one-tenth full size. The pistons each weigh about 7 lbs., or about 7·5 per cent. of the weight of the whole frame, which with two pistons weighs about 90 lbs. In an ordinary locomotive this relation will be about 660 to 110,000, or 0·6 per cent. The reciprocating parts of the model are purposely given an exaggerated weight to increase the disturbing effects and render them readily discernible. In order to show them still better, pointers are arranged for the rotation about the vertical and for the fore-and-aft movement, which multiply the motion in these directions three times. At the other end is a pencil which records the disturbances. The wheels have the rotating weights of the cranks and connecting-rods permanently balanced, and further balance-weight up to half the weight of the reciprocating parts can be added as desired. The axle is rotated by a cord from the hand-wheel lying below. At a fairly high rate of rotation the small incidental vibrations disappear and the regular oscillations corresponding to the theoretical considerations appear. The fore-and-aft movement amounts to about ¼-in., and the rotation of the pencil about 0·22 in. The former is practically the same as is found by calculation, while the rotation is somewhat higher, from some as yet unexplained cause. The magnitude of both movements is independent of the speed. With the two inside pistons connected instead of the outside, the fore-and-aft motion is the same, but the rotation is reduced to about one-quarter its former magnitude. This corresponds to the fact that the distance between the pistons is reduced from 8 ins. to 2 ins. With all four pistons connected up, so as to represent a four-cylinder locomotive, the fore-and-aft movement disappears almost entirely while the rotation is about $\frac{3}{16}$-in., or three-quarters of that observed with the two outside cylinders alone. This corresponds with the calculations, for the inside cylinders oppose the effect of the outside cylinders, but with only one-quarter of the lever-arm. In practice the rotational effect on an actual locomotive would be only about half so great for a four-cylinder locomotive as for an equally powerful engine with two outside cylinders, because the weights of the moving parts would be about one-third lighter than for the two-cylinder engine. Experiments with the model prove that the movements of the engine are small and self-limited vibrations, the period of which coincides with the time of one revolution of the driving-wheels. Their magnitude is independent of the speed of the engine, so that they do not throw any difficulty in the way of designing locomotives for extremely high speeds. The swinging of locomotives from side to side on the track has a longer



ANCHOR SPLICE FOR CREEPING RAILS.



MODEL FOR SHOWING THE DISTURBING INFLUENCES OF A LOCOMOTIVE'S RECIPROCATING PARTS.

period than the rotation. It begins at a certain speed, and increases rapidly. In order to differentiate between this movement and the rotation proper, the time of a revolution must be noted, as the period of the rotation will coincide with this. When a locomotive is running, the fore-and-aft movement takes full effect, as there is practically no resistance opposing it. With reciprocating parts weighing 660 lbs. on each side, 20 per cent. of this being balanced and a driving-wheel diameter of 86·6 ins., speeds of 62, 75, and 93 miles an hour, will correspond to 240, 300, and 360 revolutions per minute andwith a stroke of 23·6 ins., the maximum forces in the fore-and-aft direction will be respectively 10,100, 15,800, and 22,900 lbs., which on each side are set up once in each direction during every revolution. It is obvious that those rapidly varying forces strain the whole locomotive and particularly its coupling with the tender, and their effect is to set the whole vibrating. If when working with two pistons sufficient counterbalance is introduced to balance fully the weight of the reciprocating parts, the fore-and-aft oscillation and the rotational movement disappears, but excessive vertical stresses are set up which would in practice be carried by the track.—*Paper by* **Prof. v. Borries,** *presented before the Verein Deutscher Ingenieure; Rept. Rlrd. Gaz., Vol. XXXV, No. 48.—C. E. A.*

MECHANICAL.

Drop Forging.

DROP-FORGING differs from hand-forging and hammer-forging in that the shape to be formed is not obtained by slowly fashioning it with hammer, sets, and special tools, but is secured by compressing the metal in a very few blows between two dies which have been previously wrought to the desired shape. A set of dies consists of forging dies, outside trimming dies, and, if there are any holes, inside trimming dies. A pair of dies usually consists of two blocks of tool steel in which has been cut the shape to be forged. There are often two or more impressions in the same die-block; one for blocking out the metal, a roughing impression that distributes the metal and approximates the shape, and a finishing impression that brings the forging to exact shape and dimensions. The dies must be carefully designed so that there will be no place short of metal, no overlapping and consequent "cold shuts," and no unnecessary blows or waste of stock. A draft of 5 to 7 degs. from the perpendicular must be allowed, to permit a free release of the forging from the die. Good dies should be capable of making from 5,000 to 10,000 forgings. One of the dies is secured on the anvil of the drop-hammer, and the other is fastened in the head, which is free to run up and down in the guides. To raise the head some hammers employ steam, some a belt or other device, but the most characteristic method is to use a board between two friction rolls. The proportion of the weight of the head to the weight of the base is as 1 to 15 or 16. The base must rest on a deep foundation of concrete or timbers. Each drop-hammer is provided with one or two small furnaces. A very common fuel is petroleum once refined; and this, with a good burner and properly-bricked oven, gives a good, even heat, raising from 40 to 60 lbs. of steel to forging heat with 1 gal. of oil. If the piece to be forged is small, the breaking down, roughing, and finishing impressions are all in the same die, and the forger has but to pass it quickly from one impression to another until finished, when the flash is trimmed off in a press. If the piece to be forged is large, it is often roughed out under one hammer, and passed on to another to be finished. It is often found more economical to trim small forgings cold; in which case, if of high-carbon steel, they must be annealed. In general, any material that can be forged can be drop-forged, low-carbon steel being preferred to higher, because it can be heated to higher temperature for forging, thus resulting in longer life for the dies.—**D. Goddard.** *Eng. Soc. Pensyl., Rept. Mech. Wld., Vol. XXXIV, No. 879,* pp. 218–220.

WORKS MANAGEMENT.

Rapid Reduction in the Lathe as Compared with Forgings.

IN many manufacturing concerns, brass and gun-metal have been superseded by steel and cast-iron in order to reduce the cost of from 18 to 25 cents per lb. to 3 or 4 cents per lb. As the manufacturers of lathes have not the facilities for making forgings for the spindles themselves, the usual process is to furnish a blue print of the rough dimensions, to which the

forgings are then made from bars of diameters next above those of the spindles at the largest part. If the metal could be rapidly and cheaply removed from the outside, it would be much more satisfactory and economical than forging to size. In Fig. 1 is shown an ordinary lathe-carriage fitted up for this class of work. It will be seen that two slides are provided with the regular dovetail of the carriage, and are independent of each other. The front tool is adjusted longitudinally by moving the carriage, while the rear tool has an independent slide for its adjustment. The tools are provided with a wedge *W*, which has a circular bottom fitting into a corresponding slot. The five clamp bolts *B* hold the tool down firmly for heavy cuts. On large lathes the front and the rear tool block can be operated, one by a screw already in the lathe, and the other by a screw in place of the spline shaft. In smaller size lathes, the front slide is operated by means of a screw of large diameter, which is keyed to the hand-wheel *H*. This screw is hollow, and through its centre passes a shaft *C*, which carries the screw on the rear end. This screw engages with the back rest, and is operated with the ball-crank *C*. Another

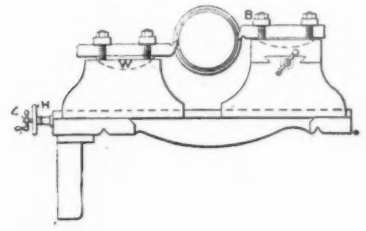


FIG. 1.

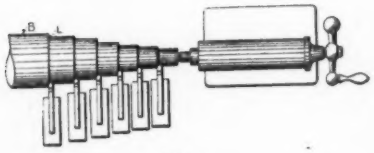


FIG. 2.

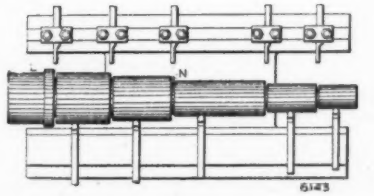


FIG. 3.

RAPID REDUCTION IN THE LATHE.

arrangement of the tools for rapid reduction is illustrated in Fig. 2. The tools in this case are arranged side by side, and are fitted up with narrow slides. *B* represents the bar which it is intended to reduce for a certain distance. As each one of the tools comes up to the line *L*, it is withdrawn independent of all others. By this multiple arrangement of tools, and by the use of high-speed tool steel, a heavy cut can be taken at a speed of 150 ft. per min. We have one other advantage in machining the spindle by this arrangement of multiple tools. In Fig. 3 the same spindle is shown. The front tools have independent adjustment, and are set up to turn to within a few thousandths of grinding size. After the spindles have been roughed off, they are caught with a lathe carrier at *L*, then the whole slide is moved bodily inward against the stop. The power feed is then thrown in, and the tools are allowed to run to the end of the steps, as shown. For grinding this spindle it must be nicked at *N*. This special slide has a tee-slot along the top portion, into which a gib and a pair of clamp bolts are fitted. The tools are adjusted to fit the grooves on a spindle which has already been turned up. The ball-crank is then turned in a direction so as to bring the tools against the work, the back stop giving the proper depth. When the stops at each end of the carriage are reached, the ball-crank is given a hard extra turn, and the slide is thus locked firmly in position. This spindle has only been used as an example of a very large variety of work which can be done in this manner, and thus considerable saving can be effected by changing over from forging to this method of rapid reduction.—**F. B. Kleinhaus,** *Eng. News, Vol. L, No. 19,* pp. 407–8.

Emery Wheel Practice in Foundries.

In many foundries I have noticed that the grinding of light castings has been done on light machines, using small wheels, and the machine has been set without any regard to its stability. If you purchase a machine with a heavy stand, having long bearings, and a large diameter of spindle, you will find that by placing it on a concrete foundation, the machine will run a great deal smoother than if it was standing on the floor. It is often the case that the wheels used are too small to give satisfactory results. The largest diameter wheel practicable should always be used for doing any kind of grinding. Another point is the belt power furnished to drive the wheel. It is very necessary that there should be belt capacity enough on the machine to keep the wheels up to speed while they are under duty. For grinding any castings in a foundry, where the man can lift the casting up to the machine, it will be found that the most economical and satisfactory results can be obtained by having a heavy machine with a 24-in. by 3-in. wheel, driven with a 5-in. belt, wheels speeded at 1,000 revolutions per minute. A recent test was made where a shaft, which had $\frac{1}{64}$-in. all round to be removed, was placed in an emery-grinding machine. At the same time a duplicate of this shaft was placed in a lathe. The grinding machine

finished the shaft in a little over 37 min., leaving it in a better condition than the lathe, on which the other shaft took 2 hrs. and 8 mins. to finish. The most recent development in the design of emery-grinding machines is a surface grinder with a circular table, similar to a boring mill, the wheel about 16 ins. by 2 ins., and automatically fed in to the centre and out to the edge. In obtaining results in emery grinding, the following points must be considered: (1) The required condition of the work when finished, whether it is to be polished when taken from the machine, or by buffing afterwards; (2) how much stock is to be removed; (3) what is the nature of the material to be ground; (4) are the pieces light or heavy, and how much metal is there in the part to be ground to absorb the heat. In regard to the grain and grade of wheels, the best results are obtained by using as coarse and as hard a wheel as possible. —**C. G. Smith,** *Pittsburg Founders' Assoc. Rept. Mod. Mach., Vol. XIV, No. 5,* pp. 128–9.

The Fixing of Piece-work Rates.

THE correct basis for piece-work rates is the least possible time required to do the operations involved satisfactorily. This time is made up of two parts:—(1) That spent in preparatory and supplementary work. (2) That spent in active work while the machine is in operation. In the jobbing-shop the average workman is not expected to accomplish work in the minimum time set. Hence the premium wage system is gaining in favour in jobbing-shops. In strictly manufacturing processes, the workman need not be the good all-round machinist that is required for jobbing-work. In fixing the time required, it is only fair to expect the man to turn out the work far more rapidly than would be expected in a jobbing-shop. It is necessary to set the piece-rate low enough to insure the earning of what the man considers his day's compensation. Where the work is heavy, time allowance will have to be made for pauses and intervals of rest. Any successful piece-work system always provides a guarantee to the workman that he will be insured against loss from causes beyond his control. This is accomplished by adopting a day-rate when circumstances warrant it. Such alteration should always be recorded by a ticket, stating the date and time of day the transfer is made, and the reason for the transfer to day-rate. In taking notes which are to serve as a basis for piece rates certain tools and instruments are necessary, namely, surface-speed indicator, revolution-counter, calipers, scales, and the stop-watch. A careful investigation and accurate determination of the speeds of all machine tools is a pre-requisite to the institution of a rate-fixing bureau. A card record should be established, indexed by departments, and cross-indexed to show all like tools, the individual cards bearing numbers coincident with the serial permanent inventory number attached to each machine tool. On these cards will be recorded the make, style, and age of the machine, together with the speed data. The proper pulley or gear combination for various diameters of stock at various cutting-speeds can also be tabulated on these record cards. After the completion of the preliminary work, the real work of rate-fixing may begin by taking observations and establishing rates on all new pieces, at

OBSERVATION MEMORANDUM

*Piece No.*_____ *Name*_____ *Material*_____ *Department doing work*_____

*Operation No.*_____ *Workmans' name and number*_____ *Machine used*_____

Name and description of operation _____

Peripheral speed (Feet per minute) _____ *R. p. m.*_____ *Revolutions to feed 1 inch* _____ *Linear feet metal removed*_____

STEP No.	STEPS IN OPERATION	STOP WATCH OBSERVATIONS 1	2	3	4	5	SUM	AVERAGE	MINIMUM

*Tool steel used*_____

Time per day spent in grinding tool _____

Time per day spent in adjusting machine _____

*Number of Tools broken per day*_____

Amount charged workman for tool breakage _____

Justifiable time per day not accounted for _____

*Remarks*_____

No. pieces man should do per day based on above _____

Highest number reported done in a day _____

Day rate paid for this class of labor _____

*Piece rate now paid*_____

Piece rate to be paid _____

Sent to _____ *Dept. No.* _____

6130

THE FIXING OF PIECE-WORK RATES.

the same time beginning operations on some single machine. A form for an observation memorandum is shown in Fig. 1. In this the items calling for time spent in grinding tools, time spent in adjusting machine, etc., would best be estimated by a whole day's observation on some typical piece of work. In addition to taking observational data, a rate-fixing department should prepare such statistical data and charts as will be valuable in checking piece-work rates. A card index of all piece rates is kept up in the department office by postings from the observation and authorisation sheets. Notices of any new pieces on which work is begun, and on which new piece rates are desired, are sent by the time-keepers to the rate-fixing department, and an observer from the rate-fixing department responds at once to this call.—**H. Diemer;** *Eng. Mag., Vol. XXVI, No. 2,* pp. 169–176.

WATER AND SANITARY.

Treatment of Sewage Containing Trade Waste.

HAVING described experiments conducted during the past five years at the Huddersfield Sewage Purification Works and their results, the author states that he did not pin his faith to septic tanks, chemical treatment, contact beds, or trickling beds, and he has brought forward, to the best of his ability, both the defects and the merits in each case. All artificial processes are far from being perfect. Each has its defects, and it is only by careful investigation that it is possible to determine the system to be applied to any particular locality. It is now generally admitted that similar results may be obtained by the use of an open septic tank as with a closed one. The author strongly emphasises this view, and trusts we shall hear less of the closed tanks in the future, at any rate, in the case of large manufacturing towns. Where the septic treatment of sewage is adopted much greater tank accommodation is necessary, the sewage having to remain in the tank 24 hours, more or less, whilst five or six hours is sufficient for chemical treatment and sedimentation. The larger tank capacity necessary in the septic process has the advantage of allowing a mixing of the strong day sewage with the weak night sewage, which is of great importance under existing conditions. Should the recommendations of the Royal Commission become law, and the manufacturers be compelled to allow their waste to flow into the sewers over an extended period, then the septic tank would have but a slight advantage over sedimentation tanks. The author is of opinion that the cleanliness of chemical treatment, or the sedimentation of sewage under aërobic conditions, the reduced tank accommodation necessary, and the slightly improved condition of the effluent for subsequent purification, should not be overlooked in making comparisons with the advantages of the septic process. With regard to the form of beds used for the purification of the tank effluent, the contact bed has now a most serious rival in the trickling bed, the wonderful amount of purification effected by the latter necessitating less than half the area of land, and thus compensating for the extra cost of the material.—**K. F. Campbell, M.Inst. C.E.,** *Jnl. San. Inst., Vol. XXIV, Part III,* pp. 497–514.—*W. N. T.*

Wrought-steel Conduits for Gravitation and Pressure Water Supply.

IN this paper the author discusses the design, manufacture, and erection of water-pipes, syphons, culverts, and flumes of varying cross section, constructed of mild steel, as distinct from those of cast steel or cast iron. In instituting comparison as to the relative advantages of steel and cast-iron mains, the chief points to be considered are efficiency and cost. In efficiency and reliability cast iron cannot compare with steel, and this is especially true of pipes of large diameters. The highest practical limit of cast-iron mains may be taken at 4 ft. diameter, and where the pressure is higher than 250 lbs. per sq. in. the diameter should not exceed 3 ft. 6 ins. The capacity of cast iron for resisting direct compressive strains, such as earth pressure in mains passing under a road, is greater than that of steel; but the latter is better adapted than cast iron to withstand shock, such as that due to subsidence of soil, or to sudden stoppage of the flow. The bursting of a pipe is of somewhat frequent occurrence with cast-iron mains, but is almost unknown with steel mains. The average price per ton of a steel main, without including transport, freight, laying in position, or making joints, may be taken as $2\frac{1}{2}$ to $3\frac{1}{2}$ times that of a cast-iron main, but the average cost per foot run is about the same for both, because the weight of the steel is about one-third that of cast-iron pipes of equal strength. As the length of a steel main varies between 18 ft. and 24 ft., and a cast-iron main between 9 ft. and 12 ft., a steel pipe line will only require half the number of joints required by a cast-iron pipe line. The author is of opinion that the chief obstacle to the use of steel for water mains has been the want of confidence amongst engineers as to the ability of a steel main to resist corrosion; this, however, may be ensured by means of a suitable coating.—**H. F. Lloyd,** *Proc. Inst. C. E., Rept. Pract. Eng., Vol. XXVIII, No. 869,* pp. 399–402.

Lowering of Water Levels in the London Basin.

THE area contributed to the London water-basin is chiefly restricted to the out-crop of the chalk, and it is only the upper chalk which possesses any storage capacity for water. That portion of the London basin covered by impermeable beds cannot be considered as available even when overlying the chalk, as the rain which falls on this area does not penetrate. Of that which falls on permeable strata overlying the chalk, only a portion percolates to the underground sources of supply. On an average soil of the home counties about a third of the total rainfall may be considered to reach the underground waters, the rest having evaporated. Percolation in some years is as small as 3 ins. out of a total of 20 ins. to 25 ins., but in normal years as much as 7 ins. Provision should be made to ensure that no greater amount is taken than can be supplied by percolation during a succession of the three driest years.

Our modern system of drainage has resulted in the diversion of about 200,000,000 gals. per diem from the metropolis, and at storm-time to 400,000,000 gals. per diem finding its way into the Thames at Crossness and Barking. The underground water finding its way into the Thames at low tide has been estimated at 50,000,000 gals. per diem. Years ago the overlying Thanet Sand became practically exhausted. In 1828 the water companies supplied the metropolis with 29,000,000 gals. per diem. Now they are supplying at the rate of about 217,000,000 gals. At the former date, the amount pumped from the chalk was only about one quarter of a million per diem, now it is about 54,000,000 gals. The aggregate amount pumped from private wells must be something enormous, and probably much in excess of that pumped by water companies. In places where, 100 years ago, the water, when tapped, would rise to the surface and overflow, the level is now over 100 ft. below ordnance datum. In 1850 the permanent levels were depressed from 50 ft. to 60 ft., and the level was falling at the rate of one foot per annum. In 1893 the fall was estimated at between 12 ins. and 18 ins. per annum. The levels are so lowered in Hertfordshire that, if pumping were discontinued, it would take 40 years of rainfall to make the levels up. A large proportion of the rainfall is required merely for maintaining the water level. Only the excess can be taken away without depressing the levels.—**C. Beadle,** *Jnl. San. Inst., Vol. XXIV, Part III*, pp. 400–403.

The Distribution of Mean and Extreme Annual Rainfall.

For the purpose of this discussion of the subject the author had employed the large collection of records of rainfall brought together by the late Mr. G. J. Symons. The records of rainfall kept up for 70 consecutive years at Chilgrove, Nash Mills, Orleton, Boston, and Kendal were discussed so as to compare the mean rainfall of various periods with that of the whole. The averages of the variations of the means of all possible groups of 10, 20, 30, and 40 consecutive years from the mean of the whole, expressed as a percentage of that mean, were as follows:—

10 years.	20 years.	30 years.	40 years.
4·7	3·4	2·2	1·7

The mean of 30 years thus appeared to be subject to very little more variation from the mean of 70 years than was the mean of 40 years; and therefore a period of 30 years was sufficient to give a close approximation to the mean rainfall of a much longer period. It was also shown that the 30 years, 1870 to 1899, gave, on the whole, a mean rainfall nearer to the true mean in all parts of the country than any other group of 30 years available for the purpose. The 380 stations yielding perfect records for the 30 years, 1870 to 1899, were not sufficiently uniform in their distribution to serve as the basis of a rainfall map, and were therefore supplemented by the records of 668 stations, which were complete for at least 20 years out of the 30, these values being reduced to the equivalent 30 years' means by the usual method. A very few shorter records, also reduced to the 30 years' means, were used for parts of Scotland and Ireland. The accuracy of the individual records was secured by using only those which had been tested and published in "British Rainfall" year by year, and also by the critical examination of the figures as set out in their proper places on a map. Isohyetal lines, or lines of equal rainfall, were drawn upon the map strictly in accordance with the figures, and without making use of any hypothesis, *e.g.* as to the effect upon rainfall of the height or exposure of the land. These lines were drawn for every 5 ins. of rainfall up to 40 ins., for every 10 ins. from 40 ins. to 60 ins., and for every 20 ins. for higher falls. With the exception of a few small specified areas, the resulting map gave as full and accurate information regarding the distribution of mean annual rainfall over the British Isles as its scale admitted. Its value lay in that it was based exclusively on definitely ascertained facts of observation, so that it might be used for the purpose of deducing the relation of rainfall to the altitude and configuration of the land, or to any other physical features. The map showed that a mean rainfall under 25 ins. occurred in three places: (1) a very narrow strip round the Moray Firth; (2) a triangular area about the Thames estuary; and (3) a large portion of east central England, south of the Humber. A rainfall between 25 ins. and 30 ins. prevailed over more than one-third of the surface of England, occupying the whole centre of the country, also over a strip along the east coast of Scotland, and in a small patch around Dublin. The rest of Scotland and Ireland received more than 30 ins. of rain, and more than 30 ins. also prevailed in four large and several small isolated portions of England. The larger of these were: (1) the whole north-west of England, including all the land more than 500 ft. in elevation from the Scottish border to beyond Derbyshire; (2) all Wales, together with a strip of the bordering districts of England; (3) the peninsula of Cornwall and Devon with prolongations eastward along the Cotswold Hills, along the Marlborough Downs and over Salisbury Plain; and (4) the higher land and the edges of the plain to leeward of it in the Weald district of Kent, Surrey, and Sussex. The smaller patches of rainfall over 30 ins. occurred on the Cleveland Hills, the North York moors, and the Yorkshire and Lincoln wolds. In all these cases there was a distinct, though not an identical, relationship between the amount of rainfall and the height and configuration of the land. The parts of England receiving a rainfall of 40 ins. and over included: (1) the Lake District, with the east of Lancashire and the west of the North and West Ridings of Yorkshire, the centre of maximum fall exceeding 100 ins. around Seathwaite; (2) the whole of Wales except Anglesea, culminating in an area with over 100 ins. round Snowdon; (3) almost all of the peninsula of Cornwall and Devon, centres of heavier fall occurring on Exmoor, Bodmin Moor, and Dartmoor. The data were rather less satisfactory for Scotland and Ireland. In Scotland it was clear, however, that a rainfall over 40 ins. was confined to the western half, the maximum (which exceeded 80 and sometimes

100 ins.) occurring in the Western Highlands, but not extending to the coast except, perhaps, in Skye. In Ireland the mountain groups of the east, and the whole of the county west of the Shannon and the Foyle, received more than 40 ins., and the fall exceeded 50 ins. in the west of Kerry, Galway, and Mayo. While a distinct relation appeared between the amount of rainfall and the configuration of the land, taken in conjunction with its elevation and exposure, the author thought that no definite numerical relation between amount of rainfall and mere height above sea-level could be made out. The average annual rainfall had been calculated by measuring the areas between successive isohyetal lines on the map; multiplying the area of each zone by the average fall within it estimated from the figures on the map, adding all the resulting volumes together for each of the great divisions, and dividing by the total area of each. The extremes of annual rainfall were discussed by taking out the figures for the driest and the wettest year of the period 1870–99 from the records of 290 stations, selected so as to be as nearly as possible uniformly distributed over the country. At 145 of these stations 1872 was the wettest year, at 92 stations 1887 was the driest year, no other year having anything like so many extremes in either case. The average of the wettest years at all stations was 3·5 ins. higher than the average of the year 1872 at the same stations; the average of the driest years was similarly 2·5 ins. lower than the average of 1887. It is shown that 1872 was probably the wettest, and 1887 probably the driest, year of the nineteenth century for the British Isles as a whole. Rainfall maps of 1872 and 1887 were prepared, and found to show a relative distribution of rainfall substantially similar to that for the 30 years' mean. The average rainfall of each of the two years has been calculated from the maps for each of the great divisions, and the results, to the nearest half-inch, together with that for the 30 years' means, were as follows:—

	Period.		
	Mean 1870-99.	Year 1872.	Year 1887.
England	31·5 ins.	45·0 ins.	23·5 ins.
Wales	49·5 ins.	74·0 ins.	36·5 ins.
Scotland	47·0 ins.	62·5 ins.	39·5 ins.
Ireland	42 0 ins.	52·0 ins.	32·0 ins.
British Isles	39·5 ins.	53·0 ins.	30·5 ins.

The excess of rainfall in 1872 was 34 per cent., and the deficiency of rainfall in 1887 was 23 per cent. of the average fall for the British Isles as a whole. The rainfall of 1872 for England and Wales was almost exactly double that of 1887.—**H. R. Mill, D.Sc., LL.D.,** *Proc. Inst. Civ. Eng., Nov., 1903.*

MISCELLANEOUS.

The Sub-aqueous Storage of Steam-Coal.

The storage in the open air means a disturbance on both sides—the chemical and the physical. Some amount of the contained gas is given off, and the oxygen of the air enters into combination with what remains to form other gases. The physical degradation due to the action of sun, wind, rain and frost, also goes steadily on. But assume that instead of being stored in air the coal is stored under water. The gases in the pores of the coal are sealed in by the water pressure, and oxidation is confined merely to the effects of oxygen in solution in the water. Coal thus stored is free from the chances of degradation. It is always protected by an interposed cushion of water, and is at a uniform temperature. Broadly, the superiority of storage under water is due to the coal being able to retain under such conditions its original physical character, and the balance of its volatile and non-volatile constituents. The coal used in the author's experiments, after being under water for periods ranging from three to ten years, could not be distinguished on the score of wetness from ordinary coal, after lying for 36 hrs. under a July sun. Not only did the coal which had lain under water for ten years retain its original power, but apparently increased it. The gain in power was also noticeable in two samples obtained from distinct sources. The author arrives at the following conclusions:—(1) Storage of steam-coal under water appears to offer economic and other advantages over storage with exposure to air, whether wholly in the open or under sheds. (2) The saving of calorific value in gain and working power is probably due to the retention more completely by the coal of its original chemical and physical properties lost in storage in air by the dissipation of natural volatile constituents, oxidation, and the weathering effects of sun, wind, rain, and frost. (3) There may be some increase in the working power of submerged coal due to its permeation by the salt of sea-water. —**J. Macaulay,** *Engineer, Vol. XCVI, No. 2496,* pp. 415–6.

The Burning of Pulverised Coal.

To burn coal in a powdered form successfully three things are necessary: (1) uniformity of moisture; (2) uniformity in size of grain; and (3) sufficient air. In a test made upon a 60 × 18-in. horizontal tubular boiler, the gross saving was found to be about 40 per cent. in the amount of coal used, but from this must be taken the cost of crushing, drying, pulverising, and feeding. In the experiment, the Rowe system was used, which consists in blowing the pulverised coal against an arch over the fire. The arch wall becomes very hot and ignites the coal, and when the proper amount of air is used the combustion is perfect. A German invention consists in covering the arch wall with a carborundum moisture, by which it can be made to withstand a heat of 3,000 degs. Fahr. or more, and to last for a long time. The cost of an outfit

for 40 tons per day of 10 hours will be about as follows :—

Dryer (estimated cost)	...	...	£300
Pulveriser ,, ,,	...	...	£500
Feeders ,, ,,	..	...	£200
Conveyors, elevators, bins, etc., necessary handling of machinery..			£400
Total ...		...	£1,400

Among other important advantages of the use of pulverised fuel is the absolute elimination of smoke.—**C. O. Bartlett,** *Jnl. Assoc. Eng. Soc., Vol. XXI, No. 1,* pp. 44–48.

Drying Coal.

In drying coal, the object is to drive off the moisture without losing any of the volatile gases or the fine particles. The use of rotary kilns for roasting ores and for burning Portland cement has, of late years, increased very rapidly, and the use of powdered coal in annealing furnaces, and in a pulverised state under boilers, has caused a rapidly increasing demand for pulverised coal. Coal, to be satisfactorily pulverised, should first be thoroughly dry. To get the best results from grinding machinery, there should not be more than one per cent. moisture. The grinding capacity of mills is nearly double on coal with one per cent. moisture to what it is with a moisture of two per cent. Some coal will give up its moisture easily and freely, and other grades will apparently grow wetter as they grow hotter. It seems that the coal in which the ash is composed largely of silica will give up its moisture easily and thoroughly, while that in which the ash is high in lime or clay is very difficult to dry, and the moisture has really to be sweated out. Coal must be handled in such a way that warm air in large quantities can be brought in contact with every particle of it. This is best accomplished by passing the currents of air from the dried material through that which is wet. Also the current of air should be subject to regulation, in order that the heat will not become so intense as to release any of the volatile matter. Do not use a machine in which particles can catch fire, and do not use a drier whose rated capacity is just enough to supply your needs. It is never safe to pass the products of combustion through the drying coal. It is generally safe in drying coal to estimate on evaporating from 6 to 8 lbs. of moisture to 1 lb. of coal or its equivalent used for fuel. Coal can generally be delivered from the drier at about 150 degs. Fahr. without loss of gas. A fan-blast must be used to get sufficient air to carry off the moisture, and this will carry with it the dust produced by crushing. The dust amounts to from 3 to 5 per cent. of the total amount of coal, and is worth saving. This is accomplished by placing the fan-blast above the receiving hopper, using suction on the cylinder, and forcing the dust and moisture into a settling chamber made of non-conducting material, preferably brick. The wall of this chamber will retain sufficient heat to prevent the moisture from condensing, and should be large enough to allow the dust to settle. The bottom of the settling chamber should slant at least 45 per cent. to the centre, which will cause the dust to slide to the middle, where it can be carried off either by screw or chain conveyor.—**C. O. Bartlett,** *Am. Mining Cong., Rept. Mech. Wld., Vol. XXXIV, No. 879,* p. 225.

Sludge Disposal Act.

A VERY troublesome question is that of sludge disposal. The most economical method of disposal at present is that of burning. Experiments in this direction have been made on a large scale by a firm of bleachers, and the result was so satisfactory that the erection of a miniature destructor is contemplated. The residual ash, being chiefly lime, proved useful as a land fertiliser. It may be of interest to the paper-maker, using waste stuffs, to know that the writer, with an average sample of dry sludge, produced a gas suitable for driving gas engines at the rate of 12,000 cub. ft. per ton. The fatty substances in an average sample of dry bleacher's sludge produced a gas of high candle-power; but the amount was small, being only 2,000 cub. ft. per ton. No doubt the fatty wastes from wool-scouring processes would produce a large volume of gas suitable for illuminating purposes, and very probably could be utilised to advantage. A provision might well be made—in any revision of the statute—to afford facility to the manufacturer to dispose of his pressed sludge by means of the local authority's refuse destructor. A large amount of trades' capital is being sunk in purification works, and in Lancashire and Yorkshire—where manufactories are to be numbered by thousands, with vast communities dependent on them for their means of livelihood, and where the effect of foreign competition is most keenly felt—it is of vital importance that the burden of the manufacturer be rendered as light as possible, and that any amendment of the Act should aim at the protection of his interests.—**A. G. Leigh,** *Jnl. San. Inst., Vol. XXIV, Part III,* pp. 486–496.

WORKSHOP PRACTICE.

This Supplement is set apart for the description of New Tools and Appliances, and for discussion of matters relating to Works Management, Tools, the Machine Shop, Foundry, Pattern Room, and General Practice, both Mechanical and Electrical. It is of prime interest to Works Managers, Foremen, etc., from whom contributions, which are paid for, are cordially invited.

Lathe Chucks, etc.

SOME account of several applications of loose jaws to ordinary face-plates, and also of a special chuck of English design, may be of interest. In the writer's first experiments with loose jaws, Barber's face-plate dogs (Fig. 1), manufactured by a Hastings firm, were used. Each jaw, or dog, consists of a base-plate secured by a stud and nut through the slot in the face-plate. The base-plate accommodates the screw which traverses the upper or sliding-jaw portion of the dog along V'd ways on the base-plate. The jaws usually have three steps. The original designs erred on the side of weakness and stinted wearing surface, but the present forms are very considerably improved in these respects, the latest having an arrangement for easily renewing the nut when worn, thus obviating the necessity of a new slide, as would formerly have been called for. The advantage of this style of jaw is its adaptability to existing face-plates, and also—on account of the round studs used for fastening—the jaws can swivel and adjust themselves to any shape of article, a decided advantage in comparison with radial jaw chucks. Their drawback, however, is, that unless prevented by solid packings in the slots, the jaws are liable to slip when the thrust necessary to hold the job is applied. Our method of obviating this inconvenience is, in the case of new lathes, to have serrations cast on each side of the slots ; on the back of the face-plates steel washers, correspondingly serrated and with holes to fit the jaw studs, allow the jaws to swivel and at the same time effectually resist the thrust. In gripping work of comparatively large area and slight thickness, or in which the contour of the work next to the jaws is irregular, it is advisable to have such means at disposal as will allow the work to bed solidly when pressed inwards by the jaws. We find tapping the front faces of the jaws and employing thin-headed steel setscrews as adjustable packings overcomes this difficulty. The scheme was pronounced by Prof. Sweet, on seeing it in operation, "as good as any for most jobs, and better for some." Face-plates as usually supplied with lathes, however, are not serrated at the back, and on our mentioning the matter to Mr. E. G. Herbert he placed a line of "radial slot" dogs (Fig. 2) on the market, each dog of which is supplied with

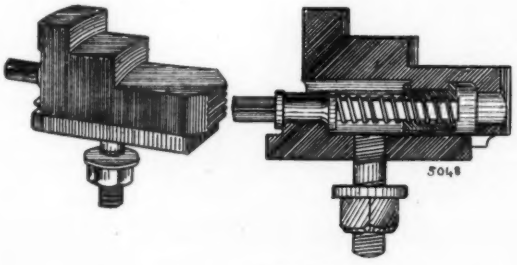


FIG. 1.—LATHE CHUCKS.

two loose racks and a plate serrated to match, the racks being affixed by screws to the back of the face-plate, giving the same effect as face-plates specially cast. Another form of chuck (Fig. 3) we have in use is manufactured by Cowley & Co., Bolton. The face-plate portion is on the lines of the ordinary English four-jaw independent chuck, but in place of the jaws being permanently attached to the face-plate they are instantly detachable ; and the face-plate, having square holes in addition to the jaw slots, may be used as an ordinary face-plate. The special feature of this chuck is that each jaw swivels on a base, and is fastened by two bolts in the manner of the English lathe compound-slide rest, thus being capable of reversing or adjusting itself to any shape of job to be held. Whilst

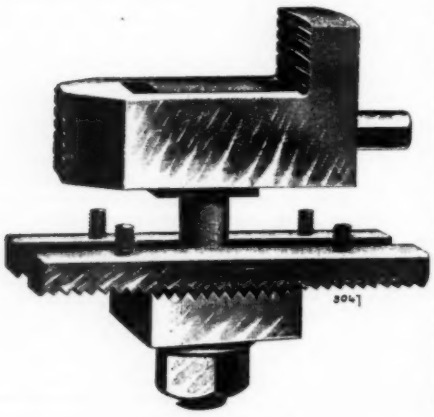


FIG 2.—LATHE CHUCKS.

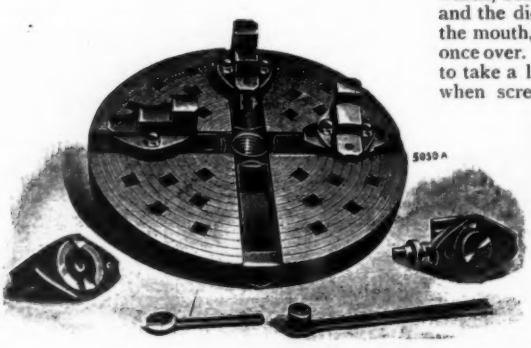


FIG. 3.—LATHE CHUCKS.

touching on the question of holding work on machines, a suggestion made by the writer in these pages a year or two ago—viz. that shaping machines might have larger tables supplied with them, so as to enable the machines to be used to their full capacity, or that supplementary or extension tables might be available—has been acted on by a firm represented in your advertising columns, and extension tables, Fig. 4, may now be had the top dimensions of which vary from 24 ins. by 12 ins. to 36 ins. by 24 ins.

The introduction of solid-drawn mild steel tubing for steam fitting purposes has brought forward special conditions to be complied with by hand and power screwing tackle, which, as yet, are scarcely provided for commercially. Machines and dies capable of satisfactorily threading wrought-iron piping often jib when confronted with the new material. The trouble arises to a great extent from the toughness and homogeneity and sometimes also hardness of the steel, which necessitates keener cutting angles than will suffice for wrought iron, thus weakening the cutting-edge, and also from the cuttings forming nodules in the die threads and tearing the threads already, perhaps, sufficiently cut. This often happens when running back-hand screw-plates. A special combination of hardness and toughness in the die steel, and also somewhat increased thickness, therefore appears called for, especially when the dies project considerably from the die-head, as in the case of screwing machines working on the smaller sizes of tube to which they are adapted. Screwing machines are generally so constructed that sufficient room is allowed for the chips to fall out of the dies, but hand screw-plates are seldom thoroughly attended to in this respect, especially the type which, being provided with a collet or bush and the dies well tapered and clearanced at the mouth, are supposed to cut a thread at once over. It is, generally speaking, advisable to take a little longer time and several cuts when screwing steel pipe by hand, as the lubricant cannot be so generously applied as in a machine. A condition which ought to be fulfilled in the case of hand screw-plates is that spare dies should be obtainable, and be actually interchangeable. So far American dies have impressed us best in this respect, though they are often not so well adapted as the British for quick releasing preparatory to taking a fresh cut. It is a good plan to have two lengths or

depths of collets, one for screwing long lengths of pipe, the other for short lengths or close up to bends. Our present favourite screw-plate—after the dies have been ground shorter for quick releasing—as regards interchangeability of dies and possibility of using short guide bushes or collets, is the "Little Giant." The actual diameter of steam pipe varys within fairly wide limits, and it may be needful to have, say, two different bores of collets for the same nominal diameter of pipe. The "Oster" and "Hart" screw-plates have universal jaw guides which will accommodate wide variations, but are not adapted for dealing with short pieces or bends. Our experience confirms that of several American correspondents of this journal, viz. that four dies on a screwing machine are better than three. An otherwise well-made machine by a good English tool-maker would not work at all with three dies, but works without trouble with four. At least one of our leading screwing-tackle makers now refuses to guarantee his usual machines, as adapted for wrought-iron pipe, to screw steel, offering a distinctly stronger and more powerful tool for the purpose. The best-looking threads are often made when the dies are very slightly dull, and sharp dies which make a scratchy thread when first used soon acquire the property of calendering or burnishing the thread whilst cutting it. Allied to this question is the behaviour of dies in turret lathes and automatic screw machines. Slight variations in the composition of the mild steel to be dealt with has not seldom caused considerable trouble in a shop, and there appears here an opportunity for some helpful correspondence from interested readers, the appearance of which we, personally, should appreciate. OBSERVER.

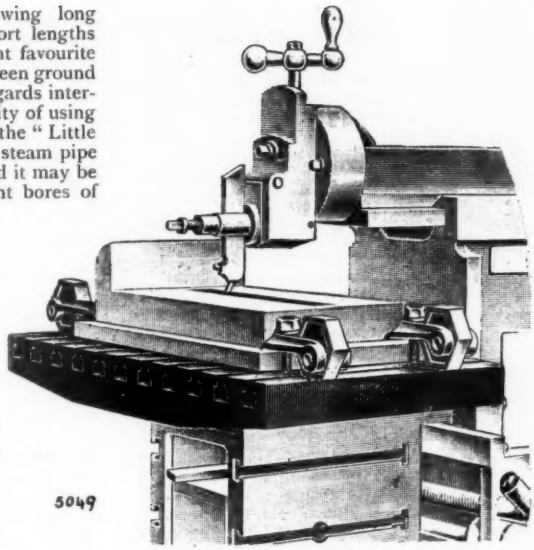


FIG. 4.—LATHE CHUCKS.

The supply of Lubricant to Machine Tools.

The ancient and time-honoured "drop-can," used so largely for lubricating work being machined, leaves much to be desired; in most cases, and with the present-day high speeds it is totally inadequate to cope with the demands made upon it. If a tank be fixed in the roof of the shop and fed from a similar tank placed a little below the ground level by means of a small centrifugal pump, we can have a constant supply of lubricant *under pressure* for each machine, which, after doing its work and being filtered by means of fine wire gauze fixed in the tray underneath the machine, may be drained back into the low-level tank by gravity and then pumped up into the tank at the highest altitude ready for use again. This system is better than the one where each machine has its own supply, for we have only one pump to keep in good repair, instead of fifty or sixty, and it is much cheaper, the piping arrangements being of the simplest character, both for feed and return. The writer knows of only one shop in which the system has been tried, but it has been such an unqualified success that he ventures to think that when it has received the consideration of works managers and foremen it will be generally adopted. H. H. B.

REPLY TO R. L. H.

Electric Cranes.

The question of the respective merits of single-motor cranes, compared with those cranes in which a motor is used for each motion, is one which enters largely into crane design. Speaking generally, and from a large experience, I should say put a motor on each motion. But circumstances make themselves

felt, and have to be considered. If the crane is one that is seldom used the initial outlay would perhaps result in a one-motor crane being employed, with the usual clutches, etc.; but then it would still be necessary to put on the heaviest motor, which, of course, would be that for hoisting. In reference to the mass of clutches referred to by your correspondent, the difference between this and the requisite reducing gear on a three-motor crane evens matters up considerably. Briefly, the advantages of a single-motor crane may be classed as follows, viz.: lighter cost for motors and applying same; lighter cost for wiring and controller. Some disadvantages are the following: the crane is not so handy to manipulate; the friction clutches are a frequent and expensive repair job; also, it is found sometimes advisable to operate the crane from the floor, or some fixed position in the shop. With the individual motor system this is easy, but with a single motor is quite the reverse. There is also the question of keeping the crane straight when travelling; say the crab is at one end of cross girder, then the power to drive the crane is delivered at one end of the shaft; then, as the torsion angle must be kept low, the shaft must be made stronger than when, as in a three-motor crane, the motor is fixed in centre of span and the power is supplied equally to each driving wheel. But even with a strong shaft, one can see the driving wheel move at one side of the crane before the other starts; hence we have cross driving. Speaking of cross driving brings to my mind another fault which is found, however, in three-motor cranes. In light cranes, say 5 tons, the cross girders are usually made of the single-web type. As the motor is usually attached to one of these, and projects some considerable distance from the web-plate, it forms an ideal arrangement for twisting the cross girder out at the top and in at the bottom. The girder yields a little, and the main travelling shaft is strained in the bearings in consequence. This fault seems to have been overlooked, and is obvious in some first-class cranes, and I have seen several that have had to be substantially stiffened for this reason. This, of course, does not apply when a single motor carried on the crab is used, as the stress comes on the girder from the crab as a pure and simple bend. One motor for each motion is undoubtedly the best, and is the system usually adopted. The controversy at present exercising minds in this work is whether spur-gear is better than worm-gear with regard to the method of supplying current; the best system is to run trolley wires along the shop, and collect by shoes and convey to controller. The wires for hoist and cross-traverse motors are sometimes placed in between the cross girders, and sometimes carried by standards attached to end carriages *over* top of crab, the shoes or collectors being *attached* to top of crab. In conclusion, I should say, if circumstances admit, use a motor on each motion, and if the crane is a heavy one have two motions for the hoist; that is, a heavy lift and an auxiliary lift with a ratio of about 4 to 1. Use liquid controllers, let the collectors have ample surface. Use magnetic brakes, and make ample allowances for losses of efficiency. Do not expect the crane to give 70 or 80 per cent. I may say that of about 40 cranes I have had to do with, of from 3 to 100 tons capacity, only about three are single-motor cranes, and probably these at an early date will be fitted with three motors each, although they are very satisfactory. The cranes, which were formerly of the square shaft type, fitted with the usual friction clutches, readily lend themselves to a one-motor conversion.

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